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GOVERNMENT RESEARCH AND DEVELOPMENT IN GREAT BRITAIN

THE question of incentives for the research worker and manager has rarely received in the past the attention it merits. In this respect, the valuable report on expenditure on research and development which has recently come from the Select Committee on Estimates for the Session 1946–47* is exceptional. This important report reviews the total estimated expenditure for 1947–48 in Government research and development, amounting to more than £69 millions. It does not consider the technical problems involved in the detailed planning and conduct of this work. The Committee is concerned rather to inquire whether in drawing up the programme the Government has provided itself with the best scientific advice available in the country, and has secured that this advice can be brought to bear on the formulation and execution of Government policy; whether the administrative organisation has been so planned as to secure the right relationship between the scientific worker and the executive and to obtain the most fruitful results from the money spent; and, above all, whether the scope and balance of the programme is such as will direct the application of scientific knowledge and effort into those fields where it is most likely to yield returns of permanent value to the nation and in such a way as will make the most efficient use of the limited resources of both money and man-power.

These are the right questions, and while a very much longer report would have been necessary to do justice to all the factors, there can be no doubt that the Committee has done its work thoroughly and provided a reassuring and encouraging answer to most of the questions. Moreover, an admirable and lucid review of the whole organisation of Government research is supported by a note on the composition and functions of the Defence Research Policy Committee and of the Advisory Council on Scientific Policy, and a series of departmental memoranda which add not a little to the information already published about the work of the Department of Scientific and Industrial Research, the Medical Research Council, the Ministry of Transport and the Board of Trade, in spite of the fact that no detailed information could be given on the work done at the research establishments of the Service Departments. That aspect of the problem is, however, to be dealt with in greater detail in a later report.

On the first of these questions the Committee welcomes the appointment both of the Advisory Council on Scientific Policy and of the Defence Research Policy Committee. Neither body has yet completed its first year of work, and it is too early to say how far these developments will succeed in securing the most efficient direction of the nation's scientific resources. On the administrative question, the distribution of functions and responsibilities among departments and other bodies appears to be illogical, and possibilities of overlapping and waste

* Report of the Select Committee on Estimates for the Session 1946–47. Pp. 132. (London: H.M. Stationery Office, 1947.) 1s. 6d. net.

of effort exist. The Committee takes the view that within limits a certain amount of overlapping can be a healthy stimulus; but it urges that the danger is best avoided by a first-class system of liaison at all levels and the freest interchange of information on projects as well as on results. Generally, the Committee appears to be satisfied that improvements in the existing organisation are being made as weak spots are revealed, and it agrees with Sir Edward Appleton's opinion that it is too early to decide what the ideal Government organisation for research should be. The organisation for fostering scientific research must remain for many years in a state of active development.

The point about free interchange of information comes up again in observations on the third question, where the Committee is both more reserved and more critical. Pointing out that in determining whether the nation's money is being well laid out within the limits of the policy implied in the Estimates, the Committee observes that the scope and balance of the programme are of great importance; money has been, and can still be, wasted by undertaking applied researches without securing that sufficient provision has been made for research into fundamental principles. In particular, it is suggested that the control of pests and the prevention of plant and animal disease might be more rapidly advanced by greater stimulus to fundamental researches in certain aspects of biology and in the specialized problems presented by viruses. Again, appropriate investigations in the social sciences might lead to lower administrative charges and to large monetary savings to the community as a whole.

These matters are commended to the attention of the Advisory Council on Scientific Policy, and at the same time the Committee stresses the value of regular, non-technical, readable, balanced and sober statements of the Government's research activities, in order to prevent undue expectations of greater and more rapid results than can be justified. It welcomes Sir Henry Tizard's indication that he hopes to publish an annual report, but, rather surprisingly, it makes no comment as to the desirability of the Department of Scientific and Industrial Research and the research councils resuming as speedily as possible the practice of issuing annual reports which was interrupted during the War. A publication policy of this type is, however, an essential element in securing the favourable political climate for research on which Dr. R. P. Russell, president of the Standard Oil Development Co., laid such stress in his recent lecture to the Industrial Research Committee of the Federation of British Industries; and in particular, the suggestion made by the Committee that Parliament should be provided periodically with comprehensive 'progress reports', setting out the range, aims and progress of Government research activities, is very much to the point.

Before discussing further the question of relations between the scientific worker and the executive, the Committee proceeds to discuss that of the scope and balance of the programme. The two questions are not, however, entirely separate, for evidence presented to the Committee showed that the pursuit of profitable new lines of research at the present time is impeded not so much by lack of money as by shortage of men and accommodation. It is clear from the way in which the Committee refers to such matters as reasonable housing accommodation for staff and to the new salary scales for the Scientific Civil Service that it is fully cognizant of those other factors in securing appropriate staff and in encouraging creative work. Specifically, it directs attention to the danger of excessive rigidity. The strict application of a code to certain types of research work, it rightly observes, may cause considerable waste of money and effort and may jeopardize the success of a costly project, besides creating an atmosphere alien to the conduct of first-class research. Moreover, not only is elasticity important in securing the right man for the right job; it is equally important in the financial control of research projects. For some projects a reasonable flexibility in the detail of expenditure is essential to the success of the research and to the most economical use of the money. Scientific workers will note with appreciation that the Committee is impressed with the economies that can accrue in such expenditure from allowing the greatest freedom compatible with safety, and it is to be hoped that the Committee's recommendation that existing arrangements should be reviewed to secure that such freedom and flexibility are more uniformly the practice will receive appropriate action.

The question of scientific staff is considered more fully in a later section of the report which comments particularly on the recommendations of the Barlow Committee on scientific man-power. Shortage of accommodation and difficulties in erecting new buildings are already hampering university expansion, and the Select Committee observes that the provision of sufficient staff and accommodation for teaching and for fundamental research at the universities should be the basis of the Government's research programme. It considers, however, that the substantially increased grants administered by the University Grants Committee should be sufficient to cover the expansion which can be undertaken in the current year. In view of recent discussions on technical colleges, it is worth noting that the Committee favours bringing more of these institutions within the university framework; but it recommends that other sources of recruitment such as engineering and other apprentices in Service establishments or in industry who receive part-time training in applied science should also be brought in, and in particular immediate action on a resolution of the British Commonwealth Scientific Official Conference regarding scholarships, studentships and maintenance grants is urged.

What most disturbs the Select Committee, however, is evidence that conditions of Government service do not always create an atmosphere attractive to research workers or conducive to scientific progress; and it refers to a number of the difficulties which were considered by the Barlow Committee on scientific staff. It attaches particular weight to eliminating the danger of isolation from active outside work in his field that may afflict the scientific

worker in departmental employment. Men of science could scarcely wish for a more pointed reference to the need for appropriate action to remedy this defect, and the Select Committee's view that attendance at the appropriate meetings of learned societies and other organisations where the all-important personal contacts can be made should be regarded as part of the duty of those in Government employment rather than as an occasion for which leave is grudgingly given, gives the individual scientific worker and his professional association all the backing that he could expect where further representations may be required.

It seems clear from such passages that much has yet to be done to implement the recommendations of the report of the Barlow Committee on scientific staff and to bring the conditions of service into line with those which Dr. Russell claimed in the lecture referred to above are most fruitful. None the less, this authoritative support for the idea of freedom in outside contacts and for the principle of a sabbatical year should go far to impress upon departmental heads the need for action along these lines, and to secure the removal of the barrier to movement between the universities and Government service which pension rights continue to offer.

Turning now to the question of the balance of the Government's research programme, the Select Committee distinguishes four aspects which require consideration: whether the sum granted for fundamental research bears a reasonable relation to that allocated to the conduct of applied research and development; whether the sum spent on directed fundamental and applied research is distributed in the best proportions between the several main lines of civil and military research; whether sufficient is being done to enable the universities to improve the quality and quantity of their human output, and whether the inducements offered are such as will attract a fair share of this output into the Government's scientific service. The views of the Select Committee on these last two aspects have already been indicated, and while on the first the Committee is reserved, holding it is a matter for experts fully informed of the amount and distribution of endowments and able to consider how far those endowments need supplementing, it is at least doubtful whether the allotment to pure research and to scientific teaching is sufficient to secure the twin objects of gaining natural knowledge which provides the foundation for the whole structure of applied science, and of providing the required output of trained research workers. Equally, it is for consideration whether the expenditure of nearly two thirds of the total sum of £76·5 millions on defence research represents an equitable distribution between civil and military needs. The relatively insignificant sum of £500,000 allocated for Colonial research is also stressed, and there are other weaknesses revealed in this admirable survey.

The Select Committee is not satisfied that the Admiralty is sufficiently flexible in its attitude to matters of common interest, and the Committee expresses the opinion that the research links between the Admiralty and the Ministry of Transport do not yet provide sufficiently for the application of scientific knowledge to improve the comfort, health and safety of the men and the proper equipment of the ships of the Merchant Navy. Here and elsewhere, the Medical Research Council is not always consulted on matters where its advice and work might be of great value. One of the weakest points in the Government organisation appears to be the absence of sufficient provision for the identification of scientific problems in day-to-day administration. This requires, as the Select Committee points out, men with wide scientific knowledge who are in daily contact with the work of their Departments, who know where the best advice can be sought or the research done, who can interpret the answer received and can advise on its special application to the administration and policy of their Departments.

That, however, is only another way of saying that scientific men are required as administrators, and that it is essential that the administrator in general should by training have acquired at least some ability to appreciate the scientific method and the scientific and technical factors in a situation or problem. That, as Dr. Russell, too, brought out, is an essential condition in the effective management of research.

A statement which has since been issued by the Association of Scientific Workers is much more critical of the organisation of Government research than is the Select Committee on Estimates, and proposes the immediate addition to the Advisory Planning Board to the Cabinet of three scientific and three technical members. In urging this, however, the Association appears to be less concerned with the balance of effort in the past than with its re-orientation to secure the immediate and effective utilization of science and technology in industry and agriculture in accordance with a plan prepared by the Advisory Council on Scientific Policy. The Association recommends, indeed, the diversion of at least a third of the scientific man-power, of laboratories and equipment of the defence services of Great Britain to civil production, challenging the present distribution of research effort between the defence services and civil production even apart from the present crisis. Similarly, it recommends steps to pool scientific research and development work in the essential industries, and to provide opportunities for scientific workers and equipment in non-essential industry to be used for more important work. The formation of regional research councils linked with the central organisation of production and research and the specific representation on production committees of scientific and technical workers are also urged in this statement, the main emphasis of which lies in the mobilization of scientific resources to improve production rather than in criticism of the organisation for co-ordination already established.

The utilization of science in connexion with the present state of emergency in Britain and elsewhere was also discussed vigorously at the Dundee meeting of the British Association, and a committee was appointed to examine the question as a matter of national urgency.

It is unfortunate that the comments by the Select Committee on Estimates on expenditure upon research into the use of atomic energy have attracted popular attention somewhat to the exclusion of the many other important matters covered by its report. No such comprehensive and detailed survey of the whole organisation of Government research in Great Britain has appeared before, and no other document brings together so conveniently quite the same range of information. Naturally, many questions require consideration in greater detail; but in the main the right questions are asked and some indication is given of the direction in which answers should be sought before the country is committed to any great or unbalanced increase of expenditure on research, whether it be for the Services, under the Department of Scientific and Industrial Research, or in any other field.

HELIUM

Helium

By Prof. W. H. Keesom. Pp. xx + 494. (Amsterdam, London and New York: Elsevier Publishing Co., 1942.) n.p.

MONOGRAPHS on the properties of a single substance are mostly rather tedious, though often useful, affairs. Helium has, however, been for many years of special interest, as the substance of lowest boiling point, and therefore an essential tool in all techniques for the production of temperatures near the absolute zero. Now, also, helium has emerged as itself the subject of intensive investigation, being the representative—actually the only terrestrial representative—of a phenomenon which might best be termed 'liquid degeneracy' and which manifests itself in a number of most striking effects occurring in the last few degrees above absolute zero.

If helium behaved as a normal substance, it would not exist as a liquid in this region, but would solidify somewhere between 2° and 3° K. Kamerlingh Onnes soon found, however, after his first liquefaction of helium, that it would not solidify under its own vapour pressure even at the lowest temperatures he could reach—about 1·5° K. At that time, curiously enough, this fact—though very useful to the low-temperature physicist—did not arouse unusual interest, nor did the equally strange fact that helium had an abnormally high volume, nearly four times that which would be predicted from the data of gas kinetics. We now know that this is due to the zero-point energy, the effect of which on physical properties becomes more marked for the low-boiling point substances. In helium it counteracts about three-quarters of the energy of attraction between atoms, 'blows it up' to its abnormal volume and prevents it from settling down to what is normally the state of lowest energy, the crystalline state. Thus as it approaches absolute zero, helium is unable to lose entropy in the ordinary way, that is, by arranging its atoms in the geometrical order of the crystal. It is true that helium can be solidified by pushing it by sheer force into a very small volume, but under its own vapour pressure helium remains liquid—and a very liquid liquid—down to the lowest temperatures.

However, although helium remains liquid, it must lose entropy if it is not to conflict with the Third Law of Thermodynamics. Many a low-temperature physicist probably hoped secretly that this law of the unattainability of absolute zero did not apply to liquids, so that by some process involving the use of liquid helium that final goal might be reached. These hopes were soon shattered, however, when in 1932 the author of the book under review discovered the so-called 'lambda' phenomenon. From this it became evident that helium changed from a more or less normal liquid into one of vanishing entropy by a transition of higher order. It was shown that helium lost its entropy rapidly below the 'lambda' point (2·18°), and that by about 1° K. the entropy had already reached an exceedingly low value. By the middle of the 1930's most of the thermodynamic data had been collected for helium in this low-temperature state, or helium II as it was termed.

In the latter part of the 1930's, chiefly as a result of developments in the technique for liquefying helium, more laboratories entered the low-temperature field and joined in the investigation of the properties of liquid helium. This was especially true of Great Britain, the United States and the U.S.S.R. There followed in quick succession a series of startling discoveries in the field of the dynamic properties of liquid helium: in 1935 the anomalous heat conductivity was discovered, in 1936 the phenomenon of the creeping film, and in 1938 the 'fountain' effect and the anomalous viscosity.

Theoretical workers soon became interested in these manifestations of what were obviously quantum effects on a macroscopic scale, and by 1939 this field had become one of leading scientific interest. The War at once interrupted developments in Britain and in the United States, and shortly afterwards in Holland and the U.S.S.R. Prof. Keesom has used this period of enforced experimental inactivity to write his book, which appeared in 1942 but only reached Great Britain late in 1945.

All known properties of helium are treated, as can be seen from the headings of the nine chapters, which are: (1) discovery, occurrence, production, commercial uses; (2) helium gas; (3) liquid and solid helium; (4) the diagram of state of helium; (5) transformations of higher orders; (6) the liquid condition; (7) the solid condition; (8) the helium atom; (9) the helium nucleus. The first three chapters, and particularly Chapter 3, will be of great value to everyone interested in low-temperature experimental techniques. The main interest is, however, in Chapters 4–7, where all the properties of helium in the liquid and solid states are discussed, with special emphasis on the newly discovered anomalous properties. At first sight the last two chapters might seem somewhat out of place, but one may be grateful for the collection of data from which the interatomic forces can be calculated, and also for the data given in Chapter 9 on the occurrence of He^3, which—as it follows a different set of statistics—may play an important part in the elucidation of the properties of this 'quantum liquid'.

One must admire in the book the very great objectivity with which every piece of work is discussed, a degree of objectivity which is greater than one could reasonably expect from one who has himself contributed so much to this field. Notwithstanding the author's detached view, the book is far more than a complete enumeration of the work done in the field; each paper has been discussed in its proper context and in relation to other work; furthermore, the author has not restricted himself to the discussion of experimental data, but has tried to make the reader

familiar with the little that is known of the theoretical interpretation. The field is still in such a state of fluidity that any other course would have been unsatisfactory.

A special feature of the book is the excellence of the abstracting; the information given is extremely well selected, and one frequently finds, on consulting the original papers, that there is little more relevant information to be found in them than that already provided by Keesom.

Thus a book has resulted which is of inestimable value to both experimental and theoretical workers in this subject, who must be very grateful indeed to Prof. Keesom for having undertaken and completed this considerable task—a task for which he was uniquely qualified. To the rapidly widening circle of physicists interested in this field, the book will be an inseparable companion, and we hope that the author, who has now retired from his chair at Leyden, will be able to present us with new editions following the rapid progress which we can expect.

The book, which is written in English, contains a number of slight eccentricities of style and grammar about which, however, this particular reviewer has perhaps no right to complain. F. E. SIMON

CHARLES-ÉDOUARD BROWN-SÉQUARD

Charles-Édouard Brown-Séquard, a Nineteenth Century Neurologist and Endocrinologist
By Prof. J. M. D. Olmsted. (Publications of the Institute of the History of Medicine, the Johns Hopkins University, Third Series: The Hideyo Noguchi Lectures, Vol. 5.) Pp. vii+253. (Baltimore, Md.: Johns Hopkins Press; London: Oxford University Press, 1946.) 3 dollars.

CHARLES-ÉDOUARD BROWN-SÉQUARD was one of the great men of nineteenth-century experimental physiology in France. His earliest discovery, probably his greatest, was that of the crossing of sensory impulses in the spinal cord. This is commemorated in neurology by the 'Brown-Séquard syndrome', a complex known to every physician and student. He did pioneer work on vasomotor nerves and on the adrenals. Throughout his life he was an indefatigable worker and, although he achieved great fame as a consulting neurologist and might have had great fortune, he directed all his energies to his experiments. Even when his qualities were recognized by appointment to a chair at the Collège de France, he was inclined to neglect teaching for research.

In his last years the quality of his work was diminished by uncritical interpretation of data in terms of a favourite hypothesis. Much of his research on epilepsy and on the inheritance of acquired characters was practically worthless.

At the end of his career he was on the threshold of great discoveries in organotherapy. What work he did on the ductless glands and upon their internal secretions produced no sound conclusions, but his concepts were instinctively prophetic.

A clear, complete, accurate and, I regret, colourless account of Brown-Séquard and his academic career is to be found in this book. Brown-Séquard was born in Mauritius of American–French parents, and he spent his early professional life in a bustle of voyages between France, America, England and Mauritius. He was a restless man, certainly a difficult man, and probably, in his early days, a disappointed man. French at heart, he was not a French subject, and was thus precluded from the higher academic posts in France. Although he eventually achieved a chair in Paris he had long to wait, and he was overshadowed by Claude Bernard.

Brown-Séquard lived in an era of giants in French medicine. They were voluble and irascible giants, and for Brown-Séquard to have made his niche at this time suggests that he cannot have lacked general acumen.

Dr. Olmsted has painted his picture of part of the scene in monotone, and there escape only suggestions of the life of the man himself.

I have never seen a full-scale biography of Brown-Séquard, but here and there in my reading I have found mentions which suggest that a less impersonal work than this would be well worth making. Dr. Olmsted's dry accounts of medical society meetings in France give no hint of the clamour which attends even the least controversial discussion. The meetings where Brown-Séquard described his experiments with testicular extracts must have been masterpieces. Even Dr. Julien Besançon, who is not noticeably reticent, retreats into Latin in describing some of Brown-Séquard's suggestions ("Les Jours de l'Homme", 1944). It is a great pity that Leon Daudet never chose to include Brown-Séquard in his collection.

Dr. Olmsted's book is excellent in all it does. The style is reminiscent of John P. Marquand at work on a Bostonian. I hope that when the author sets out to fill the gaps I have indicated he will take James Thurber (in French vein) as his model.

JAMES MARSHALL

RESERVOIRS OF WATER, WHEAT AND GOLD

Les réserves et la régulation de l'avenir dans la vie économique. (1) Avenir déterminé
By Pierre Massé. (Actualités scientifiques et industrielles, No. 1007.) Pp. 149. (Paris: Hermann et Cie., 1946.) 250 francs.

(2) Avenir aléatoire
By Pierre Massé. (Actualités scientifiques et industrielles, No. 1008.) Pp. 230. (Paris: Hermann et Cie., 1946.) 375 francs.

MATHEMATICAL economics has been too little enriched by bold analogies linking science to science. The work of M. Pierre Massé is therefore especially welcome, and deserves early translation; for, starting from his experience in hydro-electric development, he has built up a general theory of reserves. Within this theory the problems of commodity stocks and of money savings appear as special applications; and the whole is illuminated by his cross-references to the theory of reservoirs of water. M. Massé's theory does not dissolve into airy abstractions, like the work of many who try to apply general mathematical methods to the innumerable complexities of the real economic world. It has both feet firmly on the ground; its conclusions conform to common sense. The final chapter of the second volume links the argument to the 'General Theory' of Keynes; and this link to the most practical of

general economic theorists is by no means incongruous. M. Massé is in the Keynesian tradition.

The first volume deals with stock-piling for a known future, and is governed by a principle of the Maximization of Profit. The second volume discusses stock-piling against the needs of an uncertain future, and is governed by a principle of the Maximization of the Expectation of Profit. In the first case a stable solution exists in general if marginal profit is subject to decreasing returns; but there are some important special cases arising from the fact that both flow into stocks, and the level of stocks, are bounded. Stocks, for example, cannot be negative. M. Massé discusses various special types of profit-function, and then allows for the complication that birds in the hand are worth two in the bush; that the passage of time applies positive or negative rates of interest or discount to stocks and to satisfactions. Wheat deteriorates; money, set at interest, grows.

The economist's interest will quicken as he turns to the second section—to the world of probabilities, which is so much more like the real world. The profit, the mathematical expectation of which is to be maximized, must be measured in terms of satisfaction or utility rather than in terms of money, and can indeed provide a definition and a measuring-rod for the utility of money. But since a small change in a 50 per cent chance of success is psychologically quite different from a small change in a 1 per cent chance of success, the principle of the Maximization of the Expectation of Profit requires to be tempered by a principle of the Limitation of Risk; and this introduces new difficulties and indeterminacies.

M. Massé now adapts the methods of marginal analysis to an uncertain world, and discusses various types of marginal expectation of profit. The net flow into reserves may, in a given period of time, be arbitrarily given as a set of probabilities of different values; or given as a probability function of previous history (that is, of the flows in all previous periods); and the profit may also be known only in probability—as when a farmer is ignorant both of the amount and the price of his next crop. Cases of these kinds are discussed.

Enough has been said to indicate the wide interest and generality of the methods used. But it must be repeated that M. Massé is a true man of science; step by step he has tested his theories against his observation of the everyday world. Nor does he confuse the reader by an unnecessary use of mathematical symbols. He is therefore worthy of an honourable place among mathematical economists, who are too frequently obscure and too frequently fail to match their abstractions against reality.

CHARLES F. CARTER

TERPENE CHEMISTRY

The Terpenes

By Dr. J. L. Simonsen. Vol. 1: The Simpler Acyclic and Monocyclic Terpenes and their Derivatives. Second edition, revised by Dr. J. L. Simonsen and Dr. L. N. Owen. Pp. xvi + 479. (Cambridge: At the University Press, 1947.) 30s. net.

THE enormous variety of constituents to be found in the essential oils of plants constitutes one of the most impressive phenomena of organic chemistry. These fragrant oils consist usually of complex mixtures of acyclic, alicyclic, and aromatic substances. The carbon skeletons of the acyclic and alicyclic substances may be pictured as built up by the fusion of isoprene nuclei of five carbon atoms, arranged with exceedingly few exceptions in an orderly head-to-tail manner. This simple conception leads at once to molecular frameworks of terpenes composed of two or more of these nuclei, and forming acyclic, monocyclic, or polycyclic structures.

Although they are produced so lavishly in the plant world, no satisfactory conclusion has yet been formed concerning the origin and function of terpenes and their oxygenated derivatives. To the organic chemist they offer a harmonious symphony of subtle variations on an underlying molecular theme. Their delicate molecular fabrics, usually of an asymmetric cast, are of equal interest to the stereochemist. To the botanist they often provide a means of differentiating between specific or varietal forms of plants showing little morphological divergence.

British investigators, working in various parts of the world, have made noteworthy contributions to this field of organic chemistry, and it is appropriate that the outstanding modern account of the subject should stand to the credit of one of the most eminent of these investigators. Dr. Simonsen's comprehensive treatise, first issued in 1931, is valued alike by specialists in terpene chemistry and organic chemists in general.

The volume now under notice is concerned mainly with C_{10}-skeletons embracing the unsaturated hydrocarbons known as acyclic and monocyclic terpenes, respectively, and the derived alcohols, aldehydes, ketones, and oxides. In the revision the author has had the help of Dr. L. N. Owen in covering the literature until the end of 1945; in some instances even later work has been noticed. During the War, the activities of most workers in this field were interrupted, and groups of experienced workers were dispersed beyond all hope of reassemblage. Recovery will necessarily be slow in reconstituting such schools, owing to the delicate character of terpene research, in which technique and experience count for so much. Nevertheless, a great deal of new information had been gathered between 1931 and the outbreak of war. This first revised volume welcomes such interesting newcomers as angustione, dehydroangustione, leptospermone, and cryptone, from the Australian flora, and piperitenone and isopiperitenone from North Africa; it records much fresh information about the phellandrenes, menthols, carvomenthols, piperitones, piperitols, etc.; and it brings forward Ruzicka's new seven-carbon-atom ring for irone.

The plan and scope of the work remain unaltered. The first volume has been increased by about sixty pages, and a revised and enlarged edition of the original second volume is in preparation. The book is beautifully printed, with neat and clear structural formulæ, and each page carries its own documentation. For a long time essential scientific text-books and works of reference of British origin have been so difficult to obtain—in marked contrast to the efflorescence of ephemeral 'literature' in which the bookshops abound—that it is peculiarly gratifying to find a standard work of high calibre emerging from a British press during this period of eclipse. In the interests of British science and of general British prestige, it is equally imperative that established works of this kind should again become freely available and that the virtual ban existing on the publication of new British books on science should be speedily removed.

JOHN READ

LIQUID HELIUM AND ITS PROPERTIES

A CONFERENCE on the properties of liquid helium was held at the Clarendon Laboratory, Oxford, on June 27 and 28. Welcoming the guests, Prof. F. E. Simon said that the original plan had been to have a colloquium on the subject, but the response to the invitations had shown that there was widespread interest in the problem of liquid helium which seemed to justify a meeting on a larger scale. Helium, which because of its high zero-point energy remains a liquid even at absolute zero, presents a unique possibility of studying a 'quantum liquid'. With experiments starting again after the War, this was a suitable time to bring together the experimentalist and the theoretical worker. Since the War had made it difficult for many scientific workers to keep up with current fundamental research, it had been decided to open the conference with a short survey of the existing experimental data which had been compiled by Dr. K. Mendelssohn.

The main items on the first day were lectures by Prof. M. Born and Mr. H. S. Green, of Edinburgh, on their new kinetic theory of liquids, accounts of which have recently been published in the columns of *Nature*[1,2]. Two aspects of the quantized theory are of particular interest with regard to liquid helium. The first is the fact that the states of angular momentum $l = 2, 4$, etc., give no contribution at very low temperatures, which results in a radial distribution function very different from that of a normal liquid. According to calculations by Kahn, the temperature at which the last non-vanishing state of angular momentum $l = 2$ begins to disappear coincides within 0·1° with the experimentally determined change from helium I to helium II. The other aspect is the explanation of the transport phenomena in liquid helium II as being caused by a flow of heat which is normal to the direction of the mass flow. For example, the film transport is thought to be due to evaporation on the surface of the film. In the discussion following these papers the question was left open whether there is sufficient reason to assume in all the observed transport phenomena the existence of such a causative heat flow. However, the interpretation given will certainly act as a stimulus for new experiments.

One of the most fruitful approaches to a solution of the helium problem is F. London's[3] suggestion to treat it as a condensation phenomenon of a Bose–Einstein gas. It is clear that any such model based on the properties of an ideal gas will require considerable modifications if applied to a liquid where the effect of interaction between the atoms is large. A further step in this direction has been made by Dr. H. N. V. Temperley of Cambridge, who has used the 'cage model' in which each atom has a finite chance of escaping from a cage formed by its nearest neighbours. The type of periodic field chosen is that introduced by Kronig and Penney, which is easy to handle mathematically. Making plausible assumptions on the way in which the intensity of the field depends on the volume, semi-quantitative agreement with the observed equilibrium properties of helium can be obtained. In particular, it can be shown that liquid helium II must have a negative coefficient of expansion and that the zero-point energy must be high. It is hoped that the model will also lead to an interpretation of the transport phenomena.

A fundamental difficulty inherent in the model of a Bose–Einstein gas was mentioned by Dr. H. Fröhlich of Bristol. He pointed out that if this model were rigorously applied to the case of liquid helium, the density would have to be non-uniform; it would be low on the walls and increase to a maximum in the centre of the container.

A first-hand account of recent work on the anomalous transport effects in liquid helium II which has been carried out at the Kamerlingh Onnes Laboratory at Leyden was given to the conference by Dr. J. H. Mellink. Since the discovery in 1936 that liquid helium II has an extremely high heat conductivity, exceeding even that of pure metals, it has become increasingly clear that this conduction process is a somewhat complex phenomenon which cannot be expressed in the same terms as the heat flow through an ordinary liquid. The discovery in 1938 by Allen and Jones[4] of a thermo-mechanical effect (the so-called 'fountain effect') arose directly from measurements of the heat conductivity, and this has left no doubt that in liquid helium II heat flow is accompanied by mass flow. This mass transport must not, however, be regarded as an ordinary convection process. When heat is supplied to one of two volumes of liquid helium II which are connected by a capillary link, a flow of liquid will take place towards the part that is being heated. Consequently the level in the heated volume will rise at the expense of the unheated one, and a pressure difference will be set up. This pressure difference between the warm and the cold end of the capillary is bound to force back the liquid in the direction of the heat flow, and therefore it appears that the setting up of a temperature gradient must be accompanied by a counter-current of liquid inside the capillary. It is to be expected that this two-way transport of liquid adds much to the complexity of the observed phenomena; and one of the most important questions to be settled before an explanation of the effects can be essayed is the manner in which the size of the capillary link affects the flow of mass and heat.

The work carried out in Leyden by Duyckaerts, Keesom, Mellink and Meyer[5,6,7] constitutes a systematic investigation of the heat conduction and the fountain effect in capillaries ranging from 100 μ to 0·15 μ. Except for the very largest size, for which an ordinary glass capillary tube was used, the capillary link consisted of a narrow slit between two polished glass surfaces, the width of this slit being variable. With a very narrow slit the heat conductivity of liquid helium II was found to be almost a thousand times smaller than in large capillaries, but even so it is still 10^3 times greater than that of liquid helium I. Another interesting feature is the return, for very narrow slits, to a proportionality of heat flow to temperature difference, whereas in large capillaries the heat flow is proportional to the cube root of the temperature difference. The fountain effect, that is, the difference in pressure at the ends of the capillary, is found to be proportional to the heat current and, like the heat flow, becomes proportional to the temperature difference for narrow slits. In slits of medium diameter all the intermediate stages between the transport effects in large and very narrow capillaries can be traced. This transition is particularly apparent when the variation of the phenomena with the absolute temperature is considered. All the previous measurements of the heat conduction carried out with capillaries show that this quantity rises to a maximum at about 1·9° K. and

then decreases rapidly with rising temperature to reach the normal value for liquid helium II at the λ-point (2·19° K.). Using intermediate widths of slits the Leyden workers were able to show that the maximum is displaced to higher temperatures, until in the case of the narrowest slits the heat flow rises as a monotonic function of temperature, reaching a maximum value at the λ-point. The same is true for the fountain effect, and it is significant that in wider slits there exists a proportionality of heat flow and fountain effect to the applied difference in temperature for the region of low temperatures. Near the λ-point, however, where these quantities decrease with rising temperature, the proportionality is lost.

The Leyden experiments have been extended to measurements of the development and absorption of heat by liquid helium II entering and leaving a capillary. This mechano-caloric effect, which was first observed in Oxford[9] in 1939 and afterwards investigated in some detail by Kapitza[9], is the inverse of the fountain phenomenon. Like the latter, it can be considered as part of a Carnot cycle, and, as had been shown by H. London[10], its measurement can yield information about the difference in entropy between helium flowing in the capillary and the bulk liquid. In agreement with the earlier work, the Leyden experiments show that, within the limits of accuracy, the loss in entropy suffered by the liquid in the capillary is equal to the *total* entropy of the bulk liquid. One further interesting feature of the work reported by Dr. Mellink is the observation of a critical velocity of the helium passing through the slit. Once this velocity is exceeded, overheating and subsequent relaxation phenomena make their appearance. In magnitude as well as in its dependence on temperature, this critical velocity agrees closely with that observed by Daunt and Mendelssohn[11] in helium films.

A good deal of the discussion on Dr. Mellink's paper centred around the curious fact that the critical velocity in his experiments was found to be independent of the width of the slit, an observation which does not seem to agree with earlier experiments in Cambridge and Moscow, and which also does not fit in with the theoretical interpretation given by Bijl, De Boer and Michels[12]. It is clear that more measurements are needed to clarify this and a number of other obscure points; but there can be no doubt that the careful and detailed measurements of the Leyden workers constitute an important step forward in the understanding of these complex effects.

The rest of the experimental papers all dealt with the properties of the transfer film which covers all solid surfaces in contact with liquid helium II. Mr. K. R. Atkins, of the Royal Society Mond Laboratory at Cambridge, reported on three different methods for measuring the thickness of the film in relation to the height above the liquid level. Earlier experiments[13,13] had given this thickness as being of the order of 5×10^{-6} cm.; but these were integrated measurements covering heights up to 20 cm. The first type of experiment makes use of the oscillations following an equalization of level between two volumes of liquid helium II which are connected by the film. Oscillations of this type have been observed before[14], when the connecting link was a capillary filled with liquid; and they also become noticeable with films if the ratio of film width to the surface area of the free liquid is large. Making reasonable assumptions concerning the hydrodynamics of the flow, the period of the oscillation should be proportional to the thickness of the film. The second method consists in filling with liquid helium by condensation a narrow capillary to the upper end of which is attached a vessel of large surface area. Admitting successively equal amounts of helium will result in continually decreasing rises of liquid level if the thickness of the film increases rapidly with decreasing height, because at each step part of the helium is needed for thickening the film. The third method rests upon the determination of the rate of film transfer under zero pressure-head over barriers of different height. Here again assumptions have to be made about the mechanism of the flow. While the second method has as yet not yielded conclusive results, the experiments carried out so far with the first and third methods indicate that the thickness of the film is inversely proportional to the height above the liquid level, a result which does not agree with any of the existing theories[15,16].

Dr. L. C. Jackson, of Bristol, described an optical method employed by Mr. E. J. Birge and himself to measure the film thickness directly. Use is made of the change in polarization of a beam of light which is reflected on a metal plate on which a transparent film is deposited[16]. In their experiments, half the metal plate was covered with a monomolecular film of barium stearate, while the other half was covered with a layer three molecules thick. Viewing the reflected light through a quarter wave-length plate and a Nicol prism, the intensity of the two halves of the field can be made equal by a suitable setting of the latter. If now a film of liquid helium is deposited on top of the barium stearate, the Nicol must be rotated to obtain a new setting from which the thickness of the helium film can be derived. The work is still in the early stages, but the first observations suggest that the thickness measured in this way agrees with the earlier determinations.

Up to now all experiments with the transfer film rising out of the bulk liquid have been made under the vapour pressure of the latter, and it is clear that a great deal of information about the properties of the film and the transport mechanism in it might be obtained by varying the vapour pressure above the film independently. A technique for such experiments was described by Mr. J. B. Brown and Dr. K. Mendelssohn, of the Clarendon Laboratory, Oxford. Ascending from the liquid along a solid surface, the film is then allowed to enter a separate container through a great number of very fine capillaries. These capillaries readily admit helium in the form of the dense and highly mobile film, while constituting at the same time a most effective barrier against the viscous flow of the gas phase. The first experiments have shown that after the vapour pressure over the film has been temporarily reduced by pumping, it is quickly restored to what appears to be the same value as that of the free liquid. Going a step further, the film is allowed to leave the container again by a similar set of capillaries. By collecting the bulk liquid at the end of this journey, the transport along the film under reduced vapour pressure can be studied. Preliminary observations seem to indicate that under these conditions surface flow still takes place. This shows that not only will the film persist under gas pressures below the vapour pressure of the bulk liquid, but also that it must retain its characteristic properties.

The conference closed with an account and a critical survey by Prof. M. H. L. Pryce of a new (and so far unpublished) theory of super-conductivity

which had been developed by Heisenberg and his collaborators.

Space does not permit of dealing with a great number of points raised in the discussion, which throughout the conference was lively and informal. Besides those mentioned above, contributions to the discussion were made by Profs. J. F. Allen, E. N. da C. Andrade, Lord Cherwell, J. D. Cockcroft, O. R. Frisch, E. A. Guggenheim, H. Jones, R. Peierls, and Drs. R. Eisenschitz, K. Fuchs, Huang Kun, H. London, A. B. Pippard and D. Shoenberg.

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THE BOTANICAL SURVEY OF INDIA

By DR. D. CHATTERJEE

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PROF. MUNRO FOX[1] has recently given an admirable account of the Zoological Survey of India. This department has had a glorious past when viewed in the light of scientific achievements; but as the result of various restrictions of the Central Government in India, its activities during the past fifteen or twenty years have only been a shadow of those which preceded them. Its sister department—the Botanical Survey of India—has also suffered from lack of funds and retrenchment of staff, and at present is in a far worse condition than the Zoological Survey.

The Botanical Survey of India is one of the oldest of the scientific departments of the Government of India, for it was created[2] in 1892. At that time, the science of botany was served by the independent efforts of botanists scattered throughout India. The object of the Survey, as an organisation, was to co-ordinate work on plant surveys which was being carried on in institutions under the Central and the different Provincial Governments. These were: (1) the Office of the Reporter on Economic Products with the Government of India, Calcutta; (2) the Royal Botanic Garden, Calcutta, (3) the Botanic Garden, Saharanpur, (4) Office of the Government Botanist, Madras; and (5) Office of the Government Botanist, Bombay. The Botanical Survey was started with King (the late Sir George King) as the director and leading botanist, and all other departments joined him and were subordinate to him with the exception of the Reporter on Economic Products—who maintained his independent office. There were roughly four zones of the Survey.

In the north, Duthie was the director of the Saharanpur Garden. This garden—established by the East India Company—flourished so well in those days that it was often compared with the Royal Botanic Garden at Calcutta. The great reputation of the Saharanpur Garden was due to Duthie and his predecessors Royle, Falconer, King and Jameson. All of them were responsible for building a fine herbarium and putting together a good collection of Indian plants, mainly from northern India and the north-west Himalayas.

In the west, Cooke was the government botanist, Bombay, and he collected widely in the Presidency and housed his collection in the herbarium at Poona. Unfortunately, this collection was largely destroyed by a fire in 1902 and a duplicate herbarium had to be organised at the Agricultural College, Poona. This herbarium still exists. Cooke was followed by Woodrow and Gammie. Others who enriched our knowledge of botany of this part were Stocks, Ritchie, Dalzell and Gibson[3].

In the south, Lawson was the government botanist, Madras, and he was succeeded by Barber. They organised a representative herbarium of South Indian plants at Madras. This collection was transferred to Ootacamund in 1898 and was taken back to Madras after four years. But in 1910, the bulk of this herbarium was transferred to Coimbatore, where it still exists. The botany of south India was further supplemented by some good collections by Bourne, Gamble, Fischer, Fyson and Ramaswami.

In the east, the activities of the Royal Botanic Garden, Calcutta, were increased to cover areas in the east like Assam, Burma and the Andamans. Prior to the organisation of the Botanical Survey this was not possible, and planned exploration of the country was not done. The Lushai Hills of Assam were visited by Gage in 1899, the vast deltaic regions of the Ganges called the Sundribans were explored by Prain in 1902, an expedition to Central Burma was carried out by Gage in 1903, and Burkill explored the Abor Hills in north-east Assam during 1911–12. Owing to their semi-wild conditions Burma and the Andamans presented some difficulties in those days, but King was especially interested in obtaining plants from these areas. He took up the work by sending a trained collector to live and do plant-collection work in Central Burma. He also succeeded in training two convicts in plant-collection work in the Andamans. In 1899, Prain visited the Andamans with his Indian collector Shaik Mokim and brought back to Calcutta a fine series of plants. In Burma the work was greatly supplemented by the collections made by other individuals, and mention should here be made of persons like Prazer, MacGregor, Cubitt, Robertson, Rodger and Meebold. The Forest Department of Burma early in this century organised a forest herbarium at Maymyo, and this was maintained in excellent condition mainly through the efforts of Lace and Parkinson[4]. Thus the results of all these explorations were published and are now available in the first five volumes of the *Records of the Botanical Survey of India*. Besides this, the main herbarium at Calcutta received considerable addition to its collection, and some of the duplicates of sheets were sent to Kew, Edinburgh, and other herbaria in Europe.

It will be evident from the above that, from its inception until about 1923, the Botanical Survey met, in very large measure, the needs for which it was created. The possibility of overlapping of work of this Department with the Forestry and Agriculture Departments was guarded against by the creation of

a Board of Scientific Advice in 1903. This Board, however, did not meet as frequently as was expected, and as a result the Forest Department gradually gained ground at the expense of the Botanical Survey. The great objective of a complete knowledge of the vegetable covering of India and her bordering countries had to be sacrificed, and the study of geographical botany had to be greatly restricted in favour of forest botany. This is amply clear from some of the changes that followed one after the other. In 1903, Duthie retired and his post of director of the Saharanpur Garden was abolished. The herbarium was taken over by the Forest Department, and the whole collection was transferred to the Forest Research Institute, Dehra Dun, in 1910. In 1912, the Reporter of Economic Products retired and his post was also abolished. The commercial and trade problems connected with plant resources, which was previously dealt with by the Reporter, were transferred to the Botanical Survey and were dealt with by an officer entitled the Curator of the Industrial Section. The Board of Scientific Advice ceased to function and the co-ordination of plant exploration work with South India and Bombay broke down. The annual exploration grant of Rs.5,000 (about £375) was discontinued, and in 1932 a post of a botanist attached to the Calcutta Garden was withdrawn. The final blow came in 1937 when the director's post was abolished. As a result of all these, the present staff consists of only two officers and the department has languished to a state of complete stagnation.

In 1938, some Indian men of science met to consider this unhappy situation and suggested steps to be taken for the improvement of the Botanical Survey[3]. It is, however, easy to comprehend the great importance of a well-organised department like the Botanical Survey. Such a department with a central herbarium with its library and museum and some six regional herbaria would serve as a key department for the dissemination of knowledge to agriculture, forestry, pharmacology, horticulture and other departments. The problem of soil-conservation in drier parts of India could be tackled by this department. It could also assist workers in plant genetics, ecology and those interested in the introduction of exotic plants. The central herbarium should form the basis of a National Herbarium of India and should be staffed with first-class personnel. Some of these men should be specialist taxonomists on certain plant groups and others should be specialists on the geographical botany of limited areas. On a modest estimate some two dozen officers would be necessary for the central and the regional herbaria. It must be admitted that it will be difficult to find these men, and I agree with Prof. Fox's statement that there are "very few field naturalists in India". I understand that under a Government of India scheme a few young university graduates in botany are being trained in Calcutta; but beyond this, nothing is clearly known about when the Government intends to revive the Survey. This revival needs a central direction, and unless this is done at an early date, there can be no progress and consequently no benefit from botanical exploration and research.

I hope that in the new India the Government will possess men in authority with the foresight and the vision to effect among other things the early revival of the Botanical Survey of India. If it is possible to recruit men of the knowledge and qualities of those giants of the past like King, Prain, Duthie and Gage, no man of science in India need doubt that the revival of the Survey would be of the greatest help and of far-reaching benefit to India.

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[2] From the available records the year of creation of the Botanical Survey appears to be 1892, but in *Science and Culture*, 9, 110 (1945) this was given as 1889.

[3] During the last twenty years the late Rev. Blatter and his successor, the Rev. Santapau, have organised another good herbarium of western Indian plants at the St. Xavier's College, Bombay.

[4] A second herbarium was established by Rhind at the Agricultural College, Mandalay, Burma. Unfortunately, both these herbaria at Maymyo and Mandalay were completely destroyed by the Japanese during their occupation of Burma (1942–45).

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X-RAY STUDY OF ACTIN

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In a recent communication on an electron microscope and X-ray study of actin[1] a preliminary account was given of the actin fibre diagram, and a more detailed account, in a wider cytological context, was presented at the Sixth International Congress of Experimental Cytology held in July in Stockholm. The *Proceedings* of this Congress will be published in due course, but in view of the present very great interest in the muscle problem, and in actin and actomyosin in particular, it would seem appropriate also to summarize the new observations and conclusions here.

In support of conclusions already arrived at indirectly by Straub[2] and Szent-Györgyi[3], the electron microscope investigations of Jakus and Hall[4], supplemented by our own[1], show (*a*) that *F*-actin consists of fine fibrils built up by a reversible process of linear aggregation from corpuscular *G*-actin (cf. tropomyosin[5] and Waugh's fibrous insulin[6]); (*b*) that actomyosin prepared by mixing solutions of myosin and actin surpasses either of its components in the capacity of forming anastomosed fibrous networks, which are presumably the irregular counterpart of the regular, parallel combination found in muscle proper (see below); and (*c*) that these networks are dispersed on addition of adenosine triphosphate.

Thin films of *F*-actin give quite good X-ray fibre photographs when photographed with the beam parallel to the surface. The fibre period is approximately 54 A., or a multiple thereof (possibly 108 A.). These photographs are still imperfectly resolved near the centre, but we may record and direct special attention to the following reflexions on or near the meridian: ? 54, 26·8 (s +), 18·1 (m), 13·5 (m), 10·9 (s), 9·1 (s), 7·9 (m), 6·8 (s), 5·3 (vw), 4·5 (m), 4·2 (m), 3·9 (mw), 3·6 (m), 3·1 (vw), 2·8 (vw).

All muscles and mammalian keratins so far examined have been found to give the wide-angle α-diagram[7], but in addition there are seen, sometimes clearly and sometimes only vaguely, a number of meridian or near-meridian reflexions of higher spacings, which have been examined in detail particularly by MacArthur[8] and Bear[9,10,11]. For some years now an important and difficult point to decide has been the relation between these higher spacings and the ubiquitous α-diagram—whether, in fact, they constitute together a single diffraction system or not. In muscles, Bear has identified two kinds of α-type fibrils[10]. *All* muscles contain Bear's Type-II, and some muscles, such as the frog sartorius and the dog

retractor penis, contain *only* Type-II; others contain in addition Type-I (now called paramyosin[12]; it is apparently non-contractile). It was concluded later[11] that Type-II was the 'ordinary' myosin of that time (the work of the Szent-Györgyi school on actin and actomyosin had not then become generally known). Bear's meridional spacings for Type-II agree with those MacArthur had reported[8] for a frog sartorius photograph obtained in my Laboratory several years previously. It may be accepted, then, that together with the obvious α-pattern they comprise the main meridional features of the frog sartorius diffraction system.

It now turns out that both in spacings and relative intensities the observed meridional reflexions from frog sartorius and Type-II fibrils in general correspond closely to, if they are not actually the very same as, those given by isolated *F*-actin, *except that F-actin does not give the α-reflexion characteristic of isolated myosin*. Since no meridional reflexions other than those of the wide-angle α-pattern have been reported for myosin[13], the full muscle diagram is effectively the sum of the diagrams given by extracted myosin and extracted *F*-actin. In other words, it corresponds to the actomyosin complex.

We have put forward the view that the contractility of muscle tissue is a special manifestation of properties shared to varying degrees by all the members of the keratin-myosin-epidermis-fibrinogen group; that, in fact, it is the counterpart of the 'supercontraction' of keratin fibres, and that it is the consequence of a folding of the myosin chains within the myofibrils[7]. The new findings are consistent with that view and supplement it. Bailey and Perry[14] have now obtained strong evidence that not only does the interaction of myosin and actin depend on the presence of SH groups in the myosin partner, but also that the same SH groups are connected with the adenosine triphosphatase activity of the myosin: the enzyme centres combine with either actin or the triphosphate, but the affinity for the latter is so great that the actomyosin complex cannot exist in its presence. We can fit these conclusions into the framework of existing X-ray observations if we suppose that the state of folding of at least certain regions of the myosin partner is normally stabilized by combination with a parallel actin system, and that when this combination is loosened by the action of adenosine triphosphate the myosin takes up a shorter state of folding.

Hall, Jakus and Schmitt[15], in electron micrographs of the sarcomeres of skeletal muscle, have also shown that contraction is a property of the finest myofibrils, *which remain straight during contraction*, as had been inferred from X-ray studies of living muscle[7].

The general X-ray indications are that, within the deeper cytological relationships underlying the keratin-myosin-epidermis-fibrinogen group, actin stands to myosin as feather and reptilian keratin does to α-keratin. It would appear that epidermal and muscle cells have analogous capacities of synthesizing fibrous, or potentially fibrous, proteins of the α-type or of the feather keratin type; but whereas, as Rudall[16] has shown, epidermal cells exercise this function predominantly in one direction or the other, muscle cells, in their elastic mechanism, make use of both types of product.

The complete diffraction pattern of mammalian keratin[8,9] also includes meridional reflexions of the actin type. It is as though mammalian keratin were also a composite structure like the actomyosin fibrils of muscle, with an elastic component (α-keratin proper) in parallel with a corpuscular system of the same fundamental origin as feather keratin and actin.

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INTERNATIONAL ORGANISATION FOR STANDARDISATION

DURING the War the conditions prevailing in the production of war equipment, whereby the United Kingdom manufactured replacement parts for American products and the United States manufactured products to British designs, caused both countries to study each other's standards. This led, in 1943, to the Director of the British Standards Institution going to New York with the object of setting up machinery for co-ordinating the standards of the United Nations as an aid to the war effort and to discuss the formation of a temporary organisation which could act until such time as full international discussions were re-opened.

A scheme providing for the establishment of a United Nations Standards Co-ordinating Committee was evolved. Membership of the Committee, in the first instance, consisted of the national standards bodies of the British Commonwealth of Nations, the United States, the U.S.S.R., and China, and the central office (with one branch office in London and one in New York) was financed by contributions from the national standards bodies of these countries.

It became generally conceded that after the War there would be a need for the fullest collaboration in the economic field between nations, and that any international machinery set up would have to provide for the co-ordination of standards in the field of communications of all kinds (both transport and telecommunication) and the development of standards for use in connexion with the transfer across borders of raw materials and partly finished or completely finished articles.

In October 1946, on the invitation of the members of the United Nations Standards Co-ordinating Committee, representatives of twenty-five nations met in London and drafted a constitution for a permanent

international body and elected a Council of eleven nations, of which the United Kingdom is one.

The first meeting of the Council of the International Organisation for Standardisation was held in Zurich in June, 1947, under the chairmanship of its president, Mr. Howard Coonley, of the United States.

At that meeting accommodation in Geneva for the central office was approved, and Mr. Henri St. Leger, an American citizen, born in France, was appointed general secretary. A programme of work was also agreed upon for consideration by all the member bodies.

The following are among the subjects the United Kingdom has agreed to investigate from the point of view of securing international agreement:

(1) Terms, definitions and methods of test for iron and steel, rubber, coal and coke, laboratory glassware, refractories and fuel-using equipment.

(2) To consider the possibility of the unification of standards for compressed gas cylinders, with particular reference to colouring and marking systems; dimensions of valve outlets (interchangeability of connexions); filling ratios, from the safety aspect and conformity with national statutory regulations.

The United Kingdom has also agreed to act as secretariat in connexion with (*a*) the international adoption of the phon, the reference-level proposed being 2×10^{-4} dyne per cm.^{2} or 10^{-16} watts per cm.^{2}, the listening being done with both ears; (*b*) co-ordination of the various national specifications for objective noise meters; (*c*) measurement of values by subjective comparison; (*d*) measurement of sound-absorption coefficient; (*e*) confirmation of the proposed international concert pitch of 440 cycles.

While the constitution of the International Organisation for Standardisation provides for the issue of international standards, it was felt that progress would be quicker if the maximum possible unification of national standards is aimed at.

Immediately prior to the meeting of the International Organisation for Standardisation in Zurich, the Council of the International Electrotechnical Commission met to discuss affiliation of the latter with the former; as a result of which it was agreed that the International Electrotechnical Commission should become the Electrical Division of the International Organisation for Standardisation, at the same time retaining its name and technical procedure.

The Council of the International Electrotechnical Commission reviewed the work of the various advisory committees, and authorized meetings to be held as soon as practicable on the following subjects: lamp caps and holders; radio communication; measurement of radio interference; electrical accessories; extra-high voltages.

OBITUARIES

Mr. A. P. Trotter

By the death on July 23 of Alexander Pelham Trotter, at the advanced age of ninety-one, science and engineering lose another great figure linked with researches which have become classic. In his early years Mr. Trotter was concerned with dynamo manufacture, afterwards becoming editor of *The Electrician* until 1896, when he accepted a position as Government electrical engineer at the Cape of Good Hope. On return to Britain three years later he became electrical adviser to the Board of Trade, which position he held until reaching the age of retirement in 1917.

Throughout his professional career Trotter had wide interests, but he will be remembered especially for his pioneering work in the fields of illumination and photometry. His paper entitled "The Distribution of and Measurement of Illumination", read before the Institution of Civil Engineers in 1892, was remarkable, not only for the grasp of principles of street lighting which it displayed, but also for its description of the illumination photometer designed for these experiments—certainly the first instrument of this type applied to outdoor measurements in Britain. His researches on the application of dioptric glass to the distribution of artificial light, recorded some ten years earlier and illustrated by an exhibit at the Crystal Palace in 1882, were likewise much in advance of the times, and he was responsible for other work on the electric arc.

Mr. Trotter was a member of a number of leading societies and institutions, including the Institution of Electrical Engineers, before which he delivered the Faraday Lecture (again taking illumination as his subject) in 1926. But his memory will be preserved with special affection by members of the Illuminating Engineering Society, of which he was an original member and of which he served as president during 1917–20. He took a keen and active interest in the development of illuminating engineering and was associated particularly with the study of street lighting and the ultimate preparation, by a joint committee, of the first standard specification on this subject. During the First World War he presided over the Illuminating Engineering Society's committees concerned with tests of parachute flares and related problems, and he advised personally on principles of war-time street lighting, making observation trips by balloon for this purpose. He was largely responsible for the formation of a committee on illumination research, which operated afterwards for a number of years under the Department of Scientific and Industrial Research.

Mr. Trotter combined great scientific knowledge with literary facility. His two books on "Illumination, its Distribution and Measurement" and "The Elements of Illuminating Engineering" were models of lucid exposition. In presiding over meetings or contributing to discussions, his charm of manner, natural courtesy and genial humour never failed to capture the affection of his audience. J. S. Dow

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Dr. John Parkinson

JOHN PARKINSON was born in London in 1872 and studied for a time at University College. During 1897 to 1898, he worked at the Marine Biological Station at Naples on Mollusca and published a paper on the development of certain genera in the Report of the British Association in 1899. His attention turned, however, from zoology to geology, and during 1902–3 he was lecturing on that subject at Harrow School. Meanwhile, he was an undergraduate at St. John's, Cambridge, and, as an advanced student, he graduated B.A. by dissertation in 1903.

From then onwards the lines of his career became orientated, but not in the world of teaching; for the next forty years he was constantly travelling, always finding pleasure in it, and with a never-failing

enthusiasm for the immediate project. His work mainly led him to Africa, where he made surveys in Nigeria, Liberia, Kenya and Tanganyika; but for a time he was chief of the Geological Survey of Trinidad and of that of Venezuela. He also travelled for geological reasons to India, Burma, Ceylon and Canada.

During this time his work was mainly concerned with the development of mineral resources, including petroleum, although he did valuable work in connexion with water supply.

In the First World War he was engaged in an extensive survey for water supplies in East Africa and on the borders of Abyssinia. Later, for two years, 1928–29, he was leader of a British Museum expedition and turned from the economic demands of the present to the search for dinosaurian relics of the past at Tendaguru. It is significant of his range of interests and abilities that on the voyage home after this expedition he wrote the manuscript of a substantial and very readable book, "The Dinosaur in East Africa". There was no hardship for him in this task, for all his life he was intensely attracted to authorship and he found time, despite his duties and his constant travels, to write two novels. His contributions to the literature of geology were nearly fifty papers, mainly on petrology and field geology. His scientific and other abilities had long been recognized: the Geological Society awarded him the Lyell Fund in 1915, and he took his Sc.D. in 1923.

It was characteristic that, when the Second World War broke out, and he was nearly seventy years of age, he should be teaching geology in Kenya. This was no evacuation task, and he soon returned to Britain to work for the Ministry of Economic Warfare. Here, however, ill-health grew upon him and he had to retire in 1942. He died at his London home on July 19, aged seventy-five years. There are many at home and abroad who will miss him, whether in the field or at the Athenæum, for he was a good companion, knowledgeable, and with an enthusiasm that would have well become many half his age.

W. E. Swinton

Dr. H. L. Clark

Dr. Hubert Lyman Clark, formerly curator of echinoderms, more recently curator of marine invertebrates and associate professor of zoology, at the Museum of Comparative Zoology, Cambridge, Massachusetts, died on July 31, at the age of seventy-seven. In more than one hundred papers he has left a vast contribution to the knowledge of the group he loved, echinoderms. His first publication was in 1896; his latest, half a century later, in 1946. He started near home with papers on the echinoderms of the Bermudas, the West Indies and the east coast of North America. But he was to range far afield, to write of the echinoderms of most parts of the world and to make those of a distant land, Australia, his peculiar province.

The first of his bigger works, "The Apodous Holothurians. A Monograph of the Synaptidæ and Molpadidæ", came in 1907. In the same year he published "The Cidaridæ", a complete revision of that echinoid family; and the first of six parts of the fine and comprehensive "Hawaiian and other Pacific Echini" in collaboration with Alexander Agassiz. Of the remaining five parts, published between 1908 and 1917, the last three were by Clark alone. With his "North Pacific Ophiurans" in 1911 and his "Catalogue of Recent Ophiurans" in 1915, he made major contributions to the knowledge of that difficult class of echinoderms. The latter is a completely annotated list of all the living species known at that time, 1,412 in all, and is an invaluable work.

His earliest paper on Australian echinoderms, the first of a great series, was in 1909. The outcome of his first visit to the country, in 1913, was the exceedingly valuable "Echinoderm Fauna of the Torres Strait", 1921, with coloured plates which he described many years afterwards, with good reason, as having never been equalled; those of crinoids are of great beauty. Further visits to Australia in 1929 and 1932 resulted in a work of even larger scope, "Echinoderms from Australia", reviewed in *Nature* of September 24, 1938. A climax to these and his smaller Australian papers was what is perhaps his greatest work, "The Echinoderm Fauna of Australia", 1946, in which he brought together all that is known of that fauna, recent and fossil, so much of it contributed by himself. For this he received, on his deathbed, the award of the Australian Clarke Medal.

Most of his papers must go unmentioned. His immense knowledge of recent echinoderms is shown by the fact that his "Catalogue of Sea-urchins in the British Museum" was published in 1925 as the outcome of less than two months work in London in 1924; the collection contained about eight thousand specimens belonging to nearly four hundred species. He maintained his enthusiasm to the last and believed that echinoderms kept him young. In a war-time letter he proposed post-war visits to Zanzibar, to Albany, W.A., and a "really serious attack on the echinoderms of the Fiji Islands"; after which he would consent to retire, if he must. In fact, he spent the last year of his life at the Allan Hancock Foundation, Los Angeles, on a monograph of the echinoids of the eastern tropical Pacific, which he had nearly completed.

He wrote also on pterylography in birds, on variation in snakes, and on flowers.

To one who knew him only as a correspondent he was most helpful and generous to a beginner in a field where he was a master; showed himself as intensely religious and, in the first months of the Second World War, as ardently wishing that his country should throw in her lot with Britain.

D. Dilwyn John

Dr. K. Heller

Dr. Kurt Heller, a physical chemist and *privatdocent* of the former German University of Prague, died in Bern, Switzerland, on July 28 at the age of forty-nine.

Heller, a Sudeten German born at Chomutov in north-west Bohemia and an anti-Nazi, left Czechoslovakia in 1938 and eventually obtained an appointment as lecturer in chemistry at Aberystwyth. He had worked on certain aspects of radioactivity and had published papers on this subject and on the isotopes of potassium, mostly in Continental journals. He had also carried out some researches in inorganic chemistry, particularly in connexion with hypochlorites. He was a careful experimenter, and had many friends in Britain, the United States, Czechoslovakia and Switzerland. He leaves a widow and a young son.

J. G. F. Druce

NEWS and VIEWS

Conditions in the Government Scientific Service

THE Interdepartmental Scientific Panel, of which Sir Edward Appleton is chairman, is charged with rather wider responsibilities than those suggested by the Barlow Committee on Scientific Staff which recommended its establishment. The terms of reference of the Panel include keeping under review the well-being and efficiency of the Government Scientific Service and making proposals for any changes in the organisation or conditions of service which will promote those ends. Reading between the lines of the third report from the Select Committee on Estimates for the Session 1946–47, it may be surmised that there is still plenty of scope for the Panel, despite the considerable ground it has covered since it first met on March 22, 1946. A Treasury proposal for a common pool of special posts of research workers of exceptional ability above the level of principal scientific officer, and numbering about two per cent of the latter class, led to the appointment of a sub-committee under the chairmanship of Dr. C. P. Snow to consider departmental nominations, and recommendations were made and accepted (*Nature*, **159**, 464; 1947). In regard to general conditions of service, the Panel has drawn a broad distinction between attendances at meetings of learned societies and similar bodies which might be plainly regarded as proper and indeed necessary to the efficient conduct of official scientific work, and others which are desirable rather than essential to maintaining a background. While for the first of these categories duly authorized attendance should be regarded as official duty, it is recommended that attendances in the second category should be encouraged by permitting a reasonable number of attendances in official time but without payment of expenses from official funds.

The Panel has also recommended that the existing practice of setting up departmental and interdepartmental panels for regular discussions should be encouraged. The question of the movement of scientific staff has also been considered, and it is emphasized that special attention should be given to opportunities of transfer at least within a department during the earlier years of an officer's career. The Panel, however, does not consider that any general arrangement on the lines of a sabbatical year would be practicable while the current shortage of scientific men persists. It has, however, recommended that it would be appropriate on suitable occasions to allow scientific officers to undertake short courses of lectures at universities and technical colleges, and has endorsed the practice of providing speakers at the request of undergraduate societies to give talks on the scientific activities of the Service. General adoption of the practice of receiving vacation students where this can be arranged is also recommended, and in supporting the inclusion in departmental programmes of reasonably wide research topics, the Panel suggests the creation of some posts to be held on the lines of research fellowships at the universities.

It is clear that the Panel has already done much to formulate definite proposals for implementing the recommendations of the Barlow Committee. If the Panel succeeds in securing the general adoption of its own recommendations, there should be a very different note in the next report on expenditure on research and development from the Select Committee on Estimates.

Gas-Turbine Propulsion in a Naval Vessel

MESSRS. Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, have installed gas-turbine propulsion equipment in the experimental naval craft, *M.G.B.* 2009, the trials of which will take place in the near future. The Company claims that this is the first naval vessel ever to be propelled by a gas-turbine. The characteristics of the simple-cycle gas-turbine include low overall specific weight and size with rapid starting, and these qualities make it very suitable for light vessels where high speeds may be required for limited periods and at short notice. In *M.G.B.* 2009, normal cruising and astern power is provided by two 1,250 B.H.P. 2,400 r.p.m. Packard internal combustion reciprocating engines, each engine driving its own propeller through a reduction gear. Maximum ahead power is obtained by bringing into operation a completely independent Metropolitan-Vickers gas-turbine of 2,500 B.H.P., which drives a third propeller through speed-reduction gearing to supplement the power of the reciprocating engines.

The gas-turbine plant consists of a gas generator consisting of a compressor, a combustion chamber, and a turbine driving the compressor, this being followed by a power turbine mechanically independent of the compressor turbine and coupled by a reduction gear to the propeller shaft. The gas generator is the same as a jet engine which has already been developed by the Company, having a nine-stage axial flow compressor, an annular combustion chamber burning 'Pool gas oil', and a two-stage turbine. The power turbine is of the four-stage type. The hot gases on leaving the power turbine pass through a volute which turns the flow to a vertical direction at exhaust. To bring the plant into operation, the rotor of the gas generator is run up by means of a 24-volt D.C. electric starting motor to about 800–1,000 r.p.m., so establishing conditions for the satisfactory lighting of the combustion chamber. Spark ignition then takes place through the medium of a boost coil. At this low speed the power output of the turbine is insufficient to drive the compressor, so that it is necessary to continue the motoring up to about 2,000 r.p.m., when the machine becomes self-sustaining. The time for starting up the gas generator from cold and running up to the idling speed of 3,000 r.p.m. is of the order of 45 seconds.

Mr. D. McMaster

MR. DONALD MCMASTER, formerly deputy chairman of Kodak Ltd., London, recently returned to the United States to take up his new duties as vice-president and assistant general manager to the Eastman Kodak Company, Rochester, New York. Mr. McMaster is British born, but went to the United States as a boy. After attending Cornell University and the University of Buffalo, he joined the Kodak organisation at Rochester in 1917 as a chemist. Except for the First World War he remained at Rochester for eighteen years, by which time he had become assistant to the production manager. In 1935 he came to Britain as assistant manager of the Harrow works of Kodak, Ltd. In 1940 he was elected a director of Kodak, Ltd.; he became assistant deputy chairman of the board of Kodak, Ltd., in 1945, and, with Mr. E. E. Blake, joint general manager of Kodak interests in European countries. The next year he was made deputy chairman of the board of Kodak, Ltd., at the same time as Mr. Blake was appointed chairman. Mr. McMaster is an honorary fellow and a past president of the Royal Photographic Society.

Colloquium at the Dublin Institute for Advanced Studies

In July a colloquium was held at the Dublin Institute for Advanced Studies at which the following lecturers each gave a short course of lectures: Prof. C. Møller (Copenhagen), Prof. J. L. Synge (Pittsburgh), Dr. C. F. Powell (Bristol). Prof. Møller discussed the centre of gravity in relativistic quantum mechanics, explaining how this notion can be defined in a quantized field theory and how it is related to the angular momentum and the 'trembling motion'. Prof. Synge dealt with more mathematical subjects of boundary problems and multiply connected spaces. For the non-mathematician, Dr. Powell's lectures on meson tracks in the photographic emulsion were most interesting. His and Occhialini's discovery of the existence of two kinds of mesons with different masses of which the heavier decays spontaneously into the lighter kind was widely discussed. It seemed most probable that the ordinary cosmic ray meson is identical with the lighter kind, and that at least the heavier meson is the "meson of the nuclear forces" predicted by Yukawa, and is strongly coupled with nuclei. Examples of meson emission in nuclear disintegrations which were shown in the lectures also prove that the general ideas of the meson theory are correct. It is as yet an open question whether also the light meson is strongly coupled with nuclei or not. This depends on further experiments, in particular on the question whether the mesons ejected in nuclear disintegrations are all heavy or also partly light mesons. It depends also on whether the fact that ordinary negative mesons are not captured in light elements (delayed coincidence experiments) can be understood theoretically or not. If it should turn out that the light meson is also a nuclear force meson, then the form of meson theory proposed by Møller and Rosenfeld and modified by Schwinger (vector and pseudoscalar mesons with different masses) is most likely correct.

Rainfall Records of Australia

A serious gap in the official rainfall records for Australia for the period 1939–45 would not have come as a surprise, but with the receipt recently of the 1945 issue of the official "Rain Map of Australia", it is clear that there is no such gap, but only some delay in printing. The disturbance of national life caused by the War was not allowed to affect the continuity of the 1,300 selected observing stations which are used when the official monthly and annual maps are prepared, maps which are said in the opening paragraph of the notes that accompany them to give a very fair representation of the rainfall distribution over Australia. That a number of the less-important private observing stations had to be discontinued seems only too probable, especially in northern regions from which the population was evacuated and to which the strategy of 'scorched earth' was applied. Very brief study of the notes that accompany the rainfall maps for this last year of the War is sufficient to reveal the unstable character of the Australian climate.

In Great Britain snowstorms, floods, extremes of temperature and drought, such as those of the early part of 1947, can be fairly described as departures from 'normal' or 'average' conditions. In Australia such descriptions are almost without meaning. The 1945 notes show what happens when this fact is not taken into account. For example, the following appears under the heading "New South Wales": "In nearly every respect the year 1945 is possible of classification as a normal year. . . . Rainfall was well distributed during the months of January, February, May, June, July and August, but the very heavy rains that were registered in coastal divisions during April and June caused highly destructive floods on the Northern Rivers, and enormous damage was done. . . . In the Richmond Basin particularly the destruction was regarded as being greater than at any time in the history of the river." So the tale goes on. Towards the end of the year, lack of rain and short bursts of heat interfered with dairying in the metropolitan zone of that State, and made a measure of rationing necessary. Grass fires were frequent. Temperatures were "not far removed from normal", yet caused eleven deaths at Broken Hill in a 7-day spell of "high readings" at inland stations. Frosts were widespread and severe during the winter and snowfall on the Alps heavier than usual. It is scarcely necessary to quote from the descriptions of weather in the regions where the weather was not described as so nearly normal; but there is a characteristic note for Western Australia that possibly answers the natural question as to why anyone wants to live in a country with such a climate. It appears that the wheat crop there amounted to 20,500,000 bushels, in spite of excessive winter rains and insufficient "finishing rains" in the south.

Film-Strip of the Principles of Bridges

Messrs. StripSlides, 93 Cheyneys Avenue, Canons Park, Edgware, Middlesex, have submitted a copy of StripSlide No. 47/1, "The Principles of Bridges", edited by G. Ghey, of the Royal Naval College, Dartmouth. This StripSlide consists of 35 frames. The foreword to the text which accompanies it states that "it is designed for one or two lectures whose twofold object is: (i) to give a mechanics class which has been taught the principle of moments some applications of this principle in the different types of bridges; (ii) to enable people better to appreciate a bridge when they see one and to realize how the different types are related to each other. At this level the treatment is necessarily sketchy. Though the author believes that he is telling the truth, he is well aware that it is far from being the whole truth; but if thereby the audience is encouraged to think and to ask questions the cause of education will have been furthered." The film deals picturesquely, and on the whole clearly, with shearing force, bending moment, plain beams, reinforced concrete spans, cantilever bridges and suspension bridges. Examples are shown, and the theoretical treatment, although necessarily superficial, is as adequate as can be expected in a short strip. Besides fulfilling the purpose for which it is designed, it might well be used to arouse the interest of a class in preparation for a more serious course.

Archæological Research in South Africa

Research workers are usually so busy piling brick on brick on the edifice of human knowledge that there is never time for them to stand back and survey what has been built and how it has been done. The "Loom of Prehistory" (South African Arch. Soc., Handbook Series No. 2. Pp. 152), by A. J. H. Goodwin, seeks to correct this, and attempts "some analysis of the interweaving elements of time, culture, man and area in the light of past research and publication". Students of South African pre-

history will find this book of 151 pages very useful on three counts. The story of prehistoric research in the area is given, with mentions of some of the people who were particularly concerned; the situation as it is known to-day is summarized and attractively set out; a good bibliography is appended. Dr. van Riet Lowe has written two papers (*South African J. Sci.*, **42**; 1946), one concerned with a special bipolar technique of flaking found in the coastal Smithfield industries, and the other suggests that there is evidence to maintain that Stellenbosch man possessed certain artistic qualities. Some chipped stone objects have been found which seem to show a feeling for symmetry. In the same journal Dr. Malan describes the distribution and chronology of the Modderpoort culture. It is suggested that the term proto-Magosian would well describe the industries belonging to this culture.

Technical State Scholarships

THE Minister of Education has now issued the regulations (Grant Regulations No. 5 *A*) which will govern the award of technical State scholarships. These scholarships will be tenable at universities, university colleges and institutions of further education which prepare students for degrees or equivalent qualifications. In order to be eligible for an award under these regulations, a candidate must (*a*) be a British subject ordinarily resident in England or Wales, (*b*) have completed a course leading to an ordinary national certificate or diploma or a course accepted by the Minister as of equivalent standard, and be recommended for such an award by the principal of an establishment for further education, (*c*) have been in full-time or part-time attendance at such an establishment for a period of not less than two years immediately preceding August 1 of the year in which the award is made, and (*d*) be under the age of twenty on July 31 in that year. Candidates will not be eligible for these awards if they are assisted by the Minister under any other body of regulations, or if they are recognized students in training colleges in respect of which the Minister pays grant.

Smithsonian Institution Publications

A CLASSIFIED LIST of Smithsonian Publications Available for Distribution, December 1, 1946, compiled by H. Munroe, has now been issued as Publication 3858. Applicants for the papers in this list, which are distributed gratis, except where price is given, are requested to state the grounds for their requests, as the Institution is only able to supply papers as an aid to research or studies in which applicants are especially interested. Papers listed in the series of Contributions to Knowledge and Miscellaneous Collections are not public documents, and the limited editions are distributed without charge to public libraries, educational establishments and learned societies in the United States and abroad, and are supplied to other institutions and to individuals at the prices indicated. The Smithsonian Report volumes and the papers reprinted from them are distributed gratuitously by the Institution to libraries and individuals throughout the world. Many of these volumes of which the Smithsonian edition is exhausted can be purchased from the Superintendent of Documents, Government Printing Office, Washington. The Institution maintains mailing lists of libraries and educational establishments but no general mailing list of individuals.

Veterinary Educational Trust: Canine Committee

A CANINE COMMITTEE has been formed in connexion with the Veterinary Educational Trust, and Mr. F. W. Gentle will be its chairman with Mr. H. S. Lloyd as his deputy. Dr. W. R. Wooldridge, scientific director of the Trust, announced at the inaugural meeting of this Committee that the canine research station, now in the process of formation at Newmarket, will cost £25,000 to complete, and that £20,000 a year would be needed for conducting its activities. The Greyhound Racing Association had promised the Trust £10,000 a year for seven years for the work of the Newmarket station.

New Scientific Journals

Two new scientific journals, both published by the Elsevier Publishing Co., Inc., New York and Amsterdam, are *Analytica Chimica Acta*, an international journal dealing with all branches of analytical chemistry, edited by Paul E. Wenger (Geneva), published monthly, subscription 9.50 dollars per annum; and *Biochimica et Biophysica Acta*, an international journal of biochemistry and biophysics, with an editorial board, at an annual subscription of 9.00 dollars. We have received copies of the first numbers of both journals, which are of high standard. Papers are in English, French and German.

British Herpetological Society

AT the inaugural meeting held on July 11, the following were elected as the first officers of the British Herpetological Society: *President*, Dr. Malcolm A. Smith, British Museum (Natural History); *Hon. Secretary and Treasurer*, Mr. Alfred Leutscher, British Museum (Natural History) and 5 St. Margaret's Court, London, E.12; *Hon. Editor*, Dr. Angus Bellairs, Department of Anatomy, London Hospital; *Members of Committee*, Dr. Helen Spurway, Department of Zoology, University College, London, and Mr. H. W. Parker, British Museum (Natural History). It is proposed to hold meetings quarterly, if possible, in London; with an increase in membership from the provinces, outside meetings would also be considered.

Announcements

THE fifteenth Thomas Young Oration of the Physical Society will be delivered by Prof. F. Zernicke, of the University of Groningen; he will speak on "Diffraction and Optical Image Formation", and the lecture will be delivered at the Imperial College of Science and Technology, London, on September 24 at 5.10 p.m.

THE seventh series of post-graduate lectures of the London Section of the Oil and Colour Chemists' Association will be delivered by Sir Lawrence Bragg, who will give "A Review of Recent Advances in X-Ray Analysis". The lectures will be given at the Royal Institution, Albemarle Street, London, W.1, on October 2, 9 and 16 at 6.30 p.m. Admission will be by ticket only, obtainable from H. C. Worsdall, c/o Messrs. Plastanol, Ltd., Crabtree Manorway, Belvedere, Kent.

DR. LUIGI GORINI states that the communication entitled "Biochemistry of *Escherichia coli* and the Production of Penicillinase" (*Nature*, Sept. 6, p. 332) requires the following corrections: par. 3, last line, for "towards the acid or alkaline side" read "towards the alkaline side"; par. 4, line 13, for "included" read "excluded"; par. 6, line 6, for "in this way" read "on the other hand".

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

The Magnetic Field of the Moon ?

In a most comprehensive and interesting study of the magnetic field of massive rotating bodies, Prof. P. M. S. Blackett[1] has revived and discussed the formula

$$P = \beta \frac{G^{1/2}}{c} U \qquad (1)$$

for the magnetic moment P of such a body, with angular momentum U, where G denotes the gravitational constant, c the speed of light and β a constant of order unity. For the earth, taking account of the central condensation, he finds $\beta = 0{\cdot}30$. For the sun, taking its field to be that of a dipole, with polar intensity 52 gauss, and making reasonable assumptions as to its central condensation and mean angular speed, he finds $\beta = 1{\cdot}14$. For 78 Virginis, the magnetic field of which has lately been detected by H. W. Babcock[2a], by a pioneer research brilliant both in conception and execution, Blackett similarly finds $\beta = 1{\cdot}16$. More recently[2b,c], Babcock has made determinations for certain other stars, most notable being that for the peculiar A-type star B.D.—18° 3789 (HD 125248), for which the polar field is found to be 5,500 gauss; this is the strongest measured natural magnetic field, so that this star displaces sunspots as the most naturally magnetic region known.

Babcock has independently remarked[2c] that the ratio P/U is of order 10^{-11}, agreeing with Blackett's formula (1) for the earth, the sun and 78 Virginis. In a recent note he considers what this formula would imply for the magnetic field of our Milky Way system and other rotating galaxies.

In recent correspondence with Prof. Blackett, I remarked (April 18) that for the moon (1) would imply a magnetic moment less than that of the earth in the ratio $(M'/M)\,(R'/R)^2\,(\omega'/\omega)$, where M, R and ω denote the mass, radius of gyration and angular speed of the earth, and accented symbols refer similarly to the moon. Taking, in round figures, $M'/M = 1/80$, $R'/R = 1/4$, $\omega'/\omega = 1/30$, the ratio is 1/38,400. The surface field at the pole would be less than that of the earth in the ratio $(M'/M)\,(R/R')\,(\omega'/\omega)$ or 1/600, so that it would be 0·001 gauss or 100 gamma.

It will obviously be of great interest to determine whether or not the moon has a magnetic field of this order of magnitude, and thereby to test whether the validity of the formula (1) extends not only upwards from the earth to bodies the magnetic and mechanical moments of which are 10^{10} times as great, but also downwards to the moon with a mechanical moment (angular momentum) $2{\cdot}6 \times 10^{-5}$ smaller.

It might have seemed in 1939 a matter for the most speculative future to determine whether the moon has such a magnetic field, but it may at least be said that war-time technical advances have brought the possibility very much nearer. It has become feasible to measure variations of total magnetic field intensity of the order of 1 gamma by airborne magnetometers, and to signal the existence of such variations to ground stations by radio transmission; it has also become possible to impart to rockets a speed of the order required to carry them out of the earth's gravitational field, and to control their motion in part of their flight, by radio signals, from the ground. These various technical advances have been so rapid as to make it rash to deny the prospect of the accomplishment of the further advances required for the project here proposed. The rocket speed needs to be stepped up somewhat; after passing beyond the control of the earth's gravitational field it would, if well directed, be drawn moonwards by the lunar gravitational field, and perhaps some homing device (for example, depending on reflexion of radio signals from the moon's surface) could be used to bring the rocket within one or two lunar diameters from the moon's centre, or even to cause it to collide with the moon. As the surface magnetic intensity (assuming the field to be of dipole character) only varies by a factor of 2 from equator to pole, in the case of impact the intensity measurement (if it could be signalled successfully back to the earth) would check (1) to within this factor of uncertainty, which is less than the discrepancy between the values calculated by Blackett for the three bodies he considered.

Such an experiment applied to any of the planets would, of course, be incomparably more difficult, and would also not extend so greatly the range of U over which the formula (1) would be tested.

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July 22.

[1] Blackett, P. M. S., *Proc. Roy. Soc.*, A, in the press; *Nature*, **159**, 658 (1947).

[2] Babcock, H. W., (a) *Astrophys. J.*, **105**, 105 (1947); (b) *Pub. Ast. Soc. Pac.*, **59**, 112 (1947) (in the press); (c) *Phys. Rev.*, **72**, 83 (1947).

Occurrence of Upward Streamers in Lightning Discharges

For some time past it has been suspected that, at some instant during the leader process of the normal lightning discharge, streamers may be produced which rise from earth to meet the downcoming leader stroke. However, information on the lengths of such streamers has so far been lacking.

In the course of an attempt to determine from electrostatic considerations the attractive range of a lightning conductor[1], it has been possible to calculate approximately the height of the tip of the leader stroke above earth at the instant at which an upward streamer may be expected to start. This calculation was confined to the more frequent negative lightning discharge for which alone sufficient observational information is available. The results of this calculation are plotted in Fig. 1, which also shows the frequency of occurrence of lightning strokes of varying amplitudes. As a first approximation, it is now assumed that roughly one half each of the heights indicated is covered by the last downward step and the upward streamer respectively; although there are no definite data available as yet on this point, the data as they are support the assumption made. It then follows that the length of upward streamers increases with the intensity of the lightning discharge, and that for the median value of lightning strokes, upward streamers of about 16 metres may be expected for a stroke to a lightning conductor, or of 5 metres for a stroke to open ground.

Photographs of lightning flashes down to the point of contact with earth are often impossible to obtain, while in particular the detection of the rare long

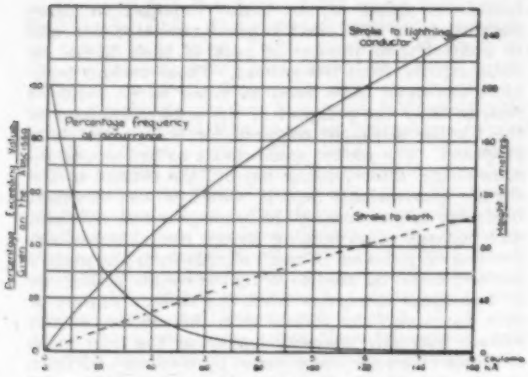

Fig. 1. HEIGHT OF TIP OF LEADER STROKE AT INSTANT AT WHICH UPWARD STREAMER MAY DEVELOP

streamers is rendered difficult by the halation produced by the heavy return stroke.

I am therefore greatly indebted to Dr. D. J. Malan, of the Bernard Price Institute, Johannesburg, South Africa, for having supplied me with a most interesting account of an upward streamer[2], and for his permission to use the information given. The sketch reproduced in Fig. 2 shows the earth terminal of a stroke which occurred on flat bare country at a distance of about 2 km. from the camera. The record was obtained with one lens of the Boys' camera stopped down, and this alone prevented the base of the main discharge channel being blurrtd by the return stroke. As can be seen in Dr. Malan's sketch, the ultimate step of the leader goes down to X, where it becomes 'ground conscious' and joins the main return channel. The height of X is of the order of 50 metres.

Applying Fig. 1 to the foregoing case, the stroke may be expected to have discharged a current amplitude of about 60–70 kiloamperes, a value which is exceeded in 5 per cent only of all discharges. Thus the only photograph which has been taken in South Africa under suitable conditions shows the presence of a pronounced streamer, and the theoretical value of the current amplitude agrees with Dr. Malan's comment that the current involved was believed to be of more than average intensity—the two estimates having been made independently and being based on entirely different considerations.

Two other relevant photographs have been taken in the United States, on beaches in New Jersey and near Pittsfield respectively. The first photograph[3] shows a pronounced upward streamer of about 3 metres length. From Fig. 1 the current intensity

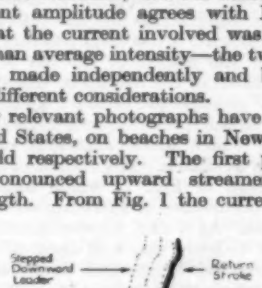

Fig. 2. SKETCH OF LOWER END OF A BOYS' CAMERA RECORD[2]

of this stroke would be estimated at 7 kiloamperes. That this stroke was, in fact, of exceptionally low intensity is strongly indicated by the absence of halation of the photograph, which was taken at a distance of only 100 ft. from the discharge.

The second case[4], which has just been reported, is not so clear, but is described as a discharge channel which is split from a height of about 1·3 metres to 12·5 metres above the shore. If this is due to an upward streamer, it suggests a current amplitude of the order of 20–30 kiloamperes. That this discharge was not of high intensity appears to be borne out by the observation that no upward streamer could be detected from two tall smoke-stacks about 400 ft. distant.

More observational evidence on this phenomenon is greatly to be desired.

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[1] Golde, R. H., *Trans. Amer. Inst. Elect. Eng.*, **64**, 902 (1945).
[2] Malan, D. J., and Collens, H., *Proc. Roy. Soc.*, A, **162**, 175 (1937) Fig. 17 (ii).
[3] McEachron, K. B., and Morris, W. A., *Gen. Elect. Rev.*, **39**, 487 (1936).
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Temperature Coefficient of Rotation of Quartz in the Ultra-Violet Region

IN the course of work on the optical constants of metals using an apparatus designed by one of us (A. M. T.), and constructed with the aid of grants from the Carnegie Trust and Royal Society, it became necessary to have an estimate of the temperature coefficient of rotation of quartz in the ultra-violet. (The rotation at temperature T_2° C. may be expressed by $\rho_2 = \rho_1 \{1 + \alpha (T_2 - T_1)\}$, where ρ_2 is the rotation at T_2° C. and ρ_1 the rotation at temperature T_1° C.) A search of the literature only yielded a coefficient for the visible spectrum. It was therefore decided to make an estimate using the apparatus itself.

At 2536 A. it was found that a change in temperature of the quartz windows from 18° C. to 32° C. produced a change in rotation of 4·9° for a total rotation due to the windows of 2,371°. This gives a value of the coefficient at 2536 A. of $1{\cdot}46 \times 10^{-4}$ with an estimated accuracy of ± 2 per cent. At 3650 A. the change was 2·0° for a total rotation of 984°, giving $1{\cdot}45 \times 10^{-4}$ as the value of the coefficient, with an estimated accuracy of ± 4 per cent. Values obtained at other wave-lengths were consistent with a value of $1{\cdot}44 \times 10^{-4}$, allowance being made for the decreasing accuracy of measurement, as the change in rotation decreases with increasing wave-length.

The value of the temperature coefficient in the visible[1] is $1{\cdot}44 \times 10^{-4}$. Our estimate of this coefficient in the ultra-violet therefore suggests that the temperature coefficient of rotation of quartz at room temperature is constant from the visible into the ultra-violet.

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[1] "Int. Crit. Tables", **2**, 336.

Oscillations of Elementary Magnets

In previous researches discussed in the papers "The Resonance of Magnetons"[1] and "Band Distribution in Magnetic Spectra"[2], it was established that there may be two types of magnetic dispersion bands. Whereas in the infra-low, acoustic and ultra-acoustic frequency-ranges the magnetic dispersion and absorption bands for ferromagnetic metals can be described by formulæ derived from the theory of magnetic viscosity spectra[3], experimental data for the centimetre wave-range fit formulæ obtained from the theory of elastic-viscous rotation of magnetic dipoles with a moment of inertia[4].

The curves in Fig. 1 are for the conservative permeability μ and the consumptive permeability ρ' of permalloy. The μ-curve, which has been theoretically computed, coincides well with the experimental points; the theoretical ρ'-curve, while representing the course of the experimental data, frequently lies somewhat below the experimental points[5,6].

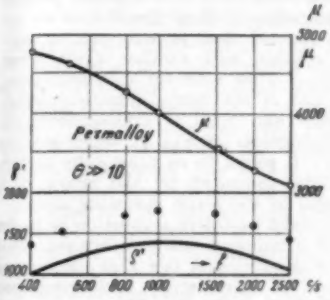

Fig. 1

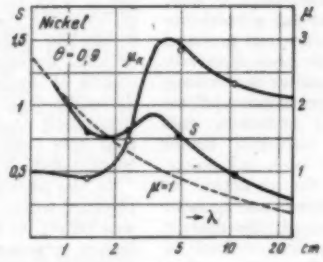

Fig. 2

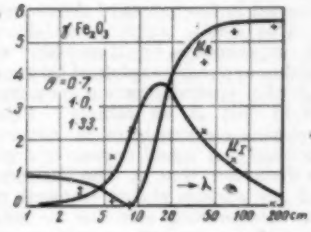

Fig. 3

In Fig. 2 the S-curve represents the magnetic absorption band of undamped electric waves along parallel nickel wires 0·2 mm. in diameter, and the μ_R-curve, the apparent consumptive permeability of the wires for wave-lengths of 1·3–11 cm.[7,8]. Then

$$S = \sqrt{\frac{\nu_R}{\lambda}} \text{ and } \mu_R = \sqrt{\mu^2 + \rho'^2} + \rho'.$$

Here μ and ρ' have been computed according to the theory of resonating dipoles[4] with a wave-length λ_0:

$$\mu = 1 + \frac{m(1-\nu^2)}{(1-\nu^2)^2+\theta^2\nu^2}, \quad \rho' = \frac{m\theta\nu}{(1-\nu^2)^2+\theta^2\nu^2},$$

where $\nu = \lambda_0/\lambda$ and θ is the measure of viscous friction. The oscillations of the dipoles become aperiodic when $\theta = 2$; their movement becomes relaxational, that is, their inertia vanishes, while the magnetization process becomes purely viscous, when θ is of the order of several tens. In computing the curves reproduced in Fig. 2, it was assumed that $\lambda_0 = 3$ cm., $m = 1$, and $\theta = 0{\cdot}9$. Other nickel wires have different characteristics.

As is seen, the experimental points are in good agreement with theory. The small value of θ ($\theta < 1$) and the small value of μ_R when $\lambda = 1{\cdot}3$ cm. ($\mu_R = 0{\cdot}85$) point to resonance, though weakly defined, of the elementary magnets.

The presence of resonance of magnetic dipoles may likewise be discerned in the μ- and ρ'-curves for the iron oxide γFe_2O_3 (bearing the notations μ_R and μ_I, respectively) recently published by Birks[9]. When eddy currents are not present in the powder particles, we apply the same magnetization law to them as to nickel, only in this case we assume that in the given oxide there are molecular magnets of three groups; their characteristics are given in the following table, where the wave of 14 cm. is the principal wave:

λ_0	3	10	14 cm.
m	0·13	0·8	3·7
θ	1·0	0·7	1·33

Just as in the case of the numeral analysis of optical dispersion and absorption curves, the permeabilities of the oxide are represented by the sums

$$1 + \Sigma(\mu - 1) = \mu_R \quad \text{and} \quad \Sigma\rho' = \mu_I.$$

These curves have been reproduced (Fig. 3), where + and × denote Birks' experimental data. The theory of resonating elementary magnets in this case, as in nickel, is in agreement with experimental data. The formulæ for the viscosity spectra do not give $\mu < 1$. Theory, based on the hypothesis that ferromagnetic metals have a non-magnetic surface layer, is inapplicable to oxides, and in metals does not give $\mu < 0{\cdot}918$ [10]. The theory of microcurrents in magnetic domains[11] leads to still broader dispersion and absorption bands.

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March 5.

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[2] Arkadiew, W., Symposium "Modern Problems of Electromagnetism" (Moscow, 1931), 51.
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[4] Arkadiew, W., *J. Russ. Ph.-Ch. Soc., Phys. pt.*, **45**, 312 (1913); *Phys. Z.*, **14**, 928 (1913).
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[6] Pilschikov, A. I., Symposium "Problems of the Ferromagnetism and of the Magnetodynamic" (Acad. Sci. U.S.S.R., 1946), 67.
[7] Arkadiew, W., and Leontiewa, A., *Z. Phys.*, **38**, 706 (1926).
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[10] Arkadiew, W., "Electromagnetic Processes in Metals" (Moscow–Leningrad, 1936), Part 2, 129, Fig. 77.
[11] Arkadiew, W., *C.R. Acad. Sci. U.S.S.R.*, **2**, 204 (1935). Also Becker, R., *Z. tech. Phys.*, **19**, 542 (1938).

Growth of 'Stimulated Crystals' and Rate of Nucleation during Recrystallization of Aluminium

In a fundamental paper, Anderson and Mehl[1] deduce from their measurements the rate of nucleation (N) (that is, the number of new grains formed per unit time in unit area) and the rate of growth during recrystallization of aluminium (G). The following remarks deal only with the dependence of these two quantities on the time of recrystallization at constant temperature. They were measured by Anderson and Mehl in very thin sheets ('two-dimensional' recrystallization) and also in much thicker sheets ('three-dimensional' recrystallization) by determining the percentage of recrystallized material and the number of new grains as a function of the time of heating. Whereas it was found that G was independent of time, in agreement with direct measurements by several investigators of the rate of growth of large crystals in fine-grained material (references in ref. 2, § 91), the remarkable result was obtained that N *increased with time*, which means that the number of new grains formed per unit surface (or unit volume) of unrecrystallized material per second increased in the course of the recrystallization process.

This result, which essentially was also observed in experiments by Kornfeld[3], is rather surprising and not so easily explained by the current conceptions of the recrystallization process. Anderson and Mehl put it as follows: "the observed curve appears autocatalytic in nature; such an autoacceleration would appear to argue for an action at a distance; that is, that the occurrence and growth of one nucleus should transmit through the matrix an accelerating stimulus to nucleation. Such a stimulus necessarily would be in the nature of a deformation."

Now the actual occurrence of such a stimulation follows with certainty from an investigation of recrystallized aluminium plates by Sandee, May and Burgers[4]. In these investigations it was found that aluminium plates with large crystals obtained by recrystallization of fine-grained material show many crystals, which appear as 'pointed' inclusions at the edge of still larger crystallites. The analysis of the form of this boundary shape, assuming for each crystallite a constant linear growing velocity in all directions, revealed the fact that the growth of such crystals did not start until another crystal, the growth of which had started previously, reached the nucleus of the 'stimulated' crystal (cf. Fig. 1). It was further

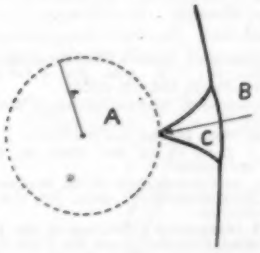

Fig. 1. Form of the grain boundary between two crystals A and C, originated under the following conditions: crystal C did not start to grow from its nuclear spot (indicated by the arrow) before crystal A had attained a size indicated by the circle with radius r. These conditions give the impression that the growth of C is in some way 'stimulated' by the approach of A. (B is an arbitrary crystal, which stops the growth of both A and C)

Fig. 2. From Anderson and Mehl's paper. Partly recrystallized aluminium sheet (× 7). The growth of the 'pointed' crystallite C (white on the photograph) has very probably been 'stimulated' by contact with the already growing crystallite A (grey on the photograph)

stated that this latter, in order to obtain a measurable size, must have a rate of growth which, at least in the beginning, must be larger than that of the 'stimulating' crystal. Here, therefore, we have a possible explanation of the observed increase of the rate of nucleation with time: it appears possible that nuclear spots, which left to themselves are not yet in a fit state to start their growth, can be made to do so by the 'contact' with another crystal which is already growing. That actually such stimulated crystals appear also in the recrystallization experiments of Anderson and Mehl is evident from the accompanying photograph (cf. Fig. 2), which is taken from their paper: it seems to us practically certain that the crystallite, indicated by the arrow, is a 'stimulated' crystal in the sense indicated above.

In the papers cited a tentative suggestion as to the physical aspect of stimulation was put forward. This was based on the experimental fact that the mutual lattice orientation of stimulating and stimulated crystal are those of a spinel twin. That means that both crystals have a glide-plane (111), and in this plane a glide-direction [110] in common. This led to the suggestion that, as soon as contact is established, something of the nature of a 'discharge' of the dislocations, held up in the nuclear spot, might be brought about along the common glide-plane and direction, which action might affect the nuclear spot in such a way that it obtains the faculty to grow. Such a mechanism of stimulating would perhaps to some extent be "in the nature of a deformation", and from this point of view somewhat akin to the explanation advanced by Hull, Colton and Mehl[5] to explain a similar effect in nucleation of pearlite from austenite.

Considerations given in a later paper[6] lead to a somewhat different suggestion. In this paper recrystallization is viewed as a process of simultaneous displacement of a system of dislocations, forming the transition layer between a 'growing' and a 'disappearing' lattice block. Such a displacement would be possible under the influence of a suitable 'shear stress', in a way similar to the displacement of a single dislocation in the glide process of a crystal (cf. W. L. Bragg[7]). It would only set in if, due to a preliminary dissolution of pairs of dislocations of 'opposite sign', the required stress was created. Now the coming in contact of a lattice block with a block in twin position may cause the sudden disappearance of a whole set of dislocations, in any event if the plane of contact were the twin plane. (It is clear that the same would happen if the two blocks had the same orientation; in that case, however, stimulation would not be visible, and only the shape of the growing crystal would be affected.) This elimination of a number of stress centres might be expected to

influence the internal stresses acting upon the dislocations forming the other boundaries of the, up to that moment, 'passive' lattice block and so induce its growth.

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[2] Burgers, W. G., "Handb. d. Metallphysik", 3, 2 (1941) (Edwards Bros., Ann Arbor, Mich., 1944).
[3] Kornfeld, M., *Phys. Z. Sowjet Union*, 7, 432 (1935); see also ref. 2, § 100.
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[7] Cf. Bragg, W. L., *Proc. Phys. Soc. London*, 52, 54 (1940).

Upper Yield Point: Occurrence in Bending Tests and Signification

Most metals when stressed, after a certain elastic deformation, undergo a permanent elongation starting at the 'yield point'. In some materials, the stress then falls to a lower value; an 'upper yield point' occurs. Its existence has been doubted, but was recently well established for tensile stress[1]. Its physical significance has scarcely been explained. Further, its existence in bending tests has been denied.

We have carried out bending experiments in the Chevenard micromachine, in preference on 1·75 mm. soft iron wire (0·035 per cent carbon) and on 2·00 mm. carbon steel (1·2 per cent carbon).

In the soft iron, the upper yield point on bending was very plain. Fig. 1 shows two curves registered for single wires. *a* is for annealed wire and shows a fairly plain upper yield point; *b* is for the same wire, but slightly cold worked (by bending around a 2-cm. wooden rod, and then straightening); no upper yield point occurs.

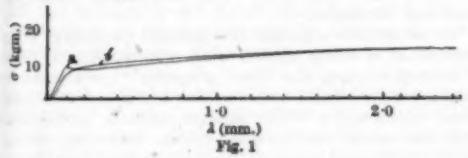

Fig. 1

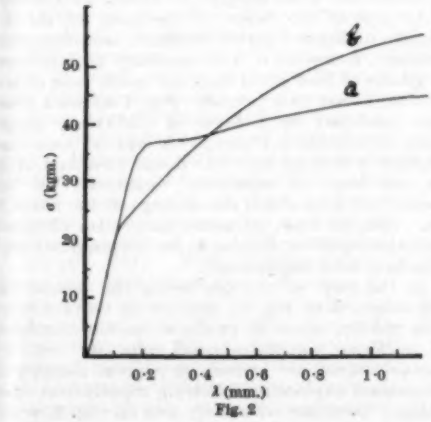

Fig. 2

In Fig. 2, for 1·2 per cent carbon steel, curve *a* is for the steel after a heat treatment which produced a precipitation of cementite (Fe_3C) along the grain boundaries; an upper yield point can be seen. Curve *b* is for the same steel, heat-treated so as to contain merely spheroidized cementite; at the beginning it coincides with *a*, then deviating with no upper yield point.

This illustrates rather well the conclusion drawn from our experiments and micrographs; namely, an upper yield point is present when some hard precipitation occurs in the grain boundaries[2]. At high carbon content, this 'hard skeleton' is cementite, a fact already presumed by A. Pomp. At low carbon content, cementite may not be entirely excluded, but microscopical observations are in favour of an oxidic skeleton.

As soon as the hard skeleton—presenting an analogy with that of many organic tissues—is mechanically destroyed, the upper yield point disappears, as evidenced by Fig. 1, *b*.

From this point of view it is quite natural that the upper yield point occurs in bending tests, too.

It is an everyday experience that, on bending an annealed soft iron wire in one's fingers, the resulting bending is generally localized at one point, instead of forming an extended arch. This is due to the presence of an upper yield point in the wire. As soon as the reinforcing skeleton is broken at some place, the continued bending takes place preferentially there.

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[1] Weibull, W., *Jernkontorets Annaler*, 126, 333 (1942).
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Large Strains and Displacements in Stress-Strain Problems

I have developed a theory that gives the relationship between the stresses and any finite values of displacement[1] and strains[2] in a loaded structure.

First consider a simple tensile test-bar under load. In this loaded bar describe an orthogonal element with edges dR_1, dR_2, dR_3 in the directions of the unit vectors $\mathbf{e}_1$, $\mathbf{e}_2$, $\mathbf{e}_3$ respectively, where $\mathbf{e}_1$ is in the direction of the load. Let the vector displacement $\mathbf{D}$ at any point have components $\mathbf{D}_1$, $\mathbf{D}_2$, $\mathbf{D}_3$. Then the relative displacement between the diagonally opposite corners of the element are,

$$d\mathbf{D} = \sum_{i=1}^{3} \mathbf{e}_i \frac{\partial D_i}{\partial R_i} dR_i. \qquad (1)$$

Now define the normal strains as,

$$e_{ii} = \partial D_i / \partial R_i. \qquad (2)$$

Noting that the elemental length dR_i is in the *strained* bar gives the definition of what I call a 'true' strain because it fits so naturally to the differential calculus analysis,

$$e = \frac{\text{stretched length} - \text{initial length}}{\text{stretched length}}. \qquad (3)$$

On this definition strain never exceeds unity. This differs from the classical definition in which division is by the initial length.

If the load in the bar is divided by the *actual* cross-sectional area, this gives the 'true' stress S_{11}.

If now Young's modulus E is defined as true stress divided by true strain then,

$$e_{11} = S_{11}/E. \quad (4)$$

Define Poisson's elastic transverse contraction ratio q with true strains and substituting (4) generalized with (2) in (1) gives the 'normal differential displacement',

$$d\mathbf{D} = \frac{S_{11}}{E}\,[\mathbf{e}_1 dR_1 - q(\mathbf{e}_2 dR_2 + \mathbf{e}_3 dR_3)]. \quad (5)$$

Now define an orthogonal element in a body loaded with a complex normal stress system S_{11}, S_{22}, S_{33}, and the same argument gives the generalization of (5) as,

$$d\mathbf{D} = d\mathbf{R} \cdot \sum_{\substack{i=1,2,3\\ j=2,3,1\\ k=3,1,2}} \frac{1}{E}\,[S_{ii} - q(S_{jj} + S_{kk})]\mathbf{e}_i\mathbf{e}_i, \quad (6)$$

where $d\mathbf{R}$ is the differential position vector joining diagonally opposite corners of the element, and the dot indicates the scalar product.

Now consider a complex shear stress system S_{12}, S_{23}, S_{31} operating on an *orthogonal* element in a loaded body. Rotational equilibrium of the element requires S_{ij} to be equal to S_{ji}. For brevity and to simplify the argument in this short note, let the edges of the element be of equal lengths. The usual rigid-body equilibrium analysis for the element gives *normal* stresses in the plane at 45° to the planes on which the shear stresses S_{ij} operate[3]. These normal stresses, which I call 'auxiliary', are of the same arithmetical value as the shear stresses. Compatible with the auxiliary normal stresses will be normal strains, and compatible with the auxiliary normal strains will be normal displacements. This argument, following precisely the lines that gave equation (6), now leads to a 'shear differential displacement',

$$d\mathbf{D} = d\mathbf{R} \cdot \sum_{\substack{i=1,2,3\\ j=2,3,1}} \frac{1}{E}\,(1+q)\,S_{ij}\,(\mathbf{e}_i\mathbf{e}_j + \mathbf{e}_j\mathbf{e}_i). \quad (7)$$

When a general complex stress system operates on an orthogonal element in the loaded body, then add equations (6) and (7) to give the total differential relative displacement suffered between the ends of the differential position vector $d\mathbf{R}$. Since $\mathbf{D}$ must be a vector point function to define the change of shape of a solid body due to load, then it can be stated in terms of the vector gradient operator as[4],

$$d\mathbf{D} = d\mathbf{R} \cdot \nabla\mathbf{D}. \quad (8)$$

Since $d\mathbf{R}$ is an arbitrary vector about the point considered, then

$$\nabla\mathbf{D} = \frac{1}{E} \sum_{\substack{i=1,2,3\\ j=2,3,1\\ k=3,1,2}} \left\{ \begin{matrix} [S_{ii} - q(S_{jj} + S_{kk})]\mathbf{e}_i\mathbf{e}_i \\ +(1+q)\,S_{ij}(\mathbf{e}_i\mathbf{e}_j + \mathbf{e}_j\mathbf{e}_i) \end{matrix} \right\}. \quad (9)$$

This expression has been evolved *without restriction on the value of displacement or its rate of change with position.*

I call $\mathbf{D}$ the 'straining displacement' because it is the body vector displacement freed from overall rigid-body displacements. This is secured by not allowing the translation or rotation of the axes of the strain ellipsoid at any one arbitrary point in the loaded body.

The same type of reasoning that gave (9) for an elastic isotropic body allows one to introduce the inelastic or post-yield stresses[5]. Also, further consideration on the same lines shows that (9) is true whether the co-ordinate system is orthogonal, cartesian or curvilinear, in which latter case the $\mathbf{e}_i$'s have local values at each point in the loaded body. Yet again the equation for the anisotropic body can be evolved in similar fashion, with only the restriction that a normal stress produces a normal strain[6]. A treatise on the complete general treatment is in preparation.

An important use of a generalized theory for large displacements and strains is to interpret into stresses the large strains frequently measured[7] in structural tests.

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Properties of Liquid Explosives

IT has been shown[1] that many liquid explosives resemble nitroglycerine in their extreme sensitivity to impact if bubbles of air are entrapped in the liquid and compressed during the collision of the impacting surfaces. Under the conditions of both 'cavity' and 'droplet' impact tests, nitroglycol, methyl nitrate, 'Myrol' (methyl nitrate and 33 per cent methyl alcohol by volume), diglycerol tetranitrate, diethylene glycol dinitrate and mixtures of tetranitromethane and toluene (ranging in composition from approximately 15 to 60 per cent toluene by volume) all showed an enormous increase in explosion sensitivity (in decreasing order of resultant sensitivity).

To determine whether the general explosion characteristics of these liquids were also similar to those of nitroglycerine, the blast patterns[2,3] produced by thin layers confined between flat brass surfaces have been examined. With methyl nitrate, nitroglycol and the tetranitromethane/toluene mixtures, explosion was effected quite simply by causing a condenser spark to pass at the centre of the disks (cf. ref. 2). To initiate diethylene glycol dinitrate and diglycerol tetranitrate, however, it was necessary to introduce a few grains of lead azide into the spark hole of the upper disk to act as a primer. Fig. 1 shows a blast pattern produced by a layer of diethylene glycol dinitrate (thickness 0·1 mm.). It will be seen that the surface is divided into two distinct regions, *A* in which the brass is relatively unaffected by the explosion, and *B* in which the damage to the metal is severe. Similar blast patterns have been obtained with all the liquid explosives so far investigated (and with molten solid explosives[3]).

As in the case of nitroglycerine, the second explosive stage, *B* in Fig. 1, appears to be of discontinuous nature, since it produces in the confining metal surfaces numerous small pits (cf. ref. 2). Presumably these are caused by a great number of very localized explosions following rapidly one upon the other; they can be clearly seen in Fig. 2, which

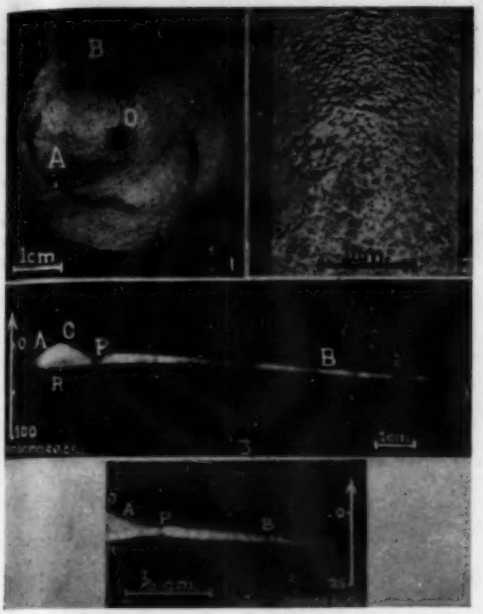

Fig. 1. DIETHYLENE GLYCOL DINITRATE BLAST PATTERN. INITIATION BY AZIDE IN SPARK HOLE *O*

Fig. 2. PIT MARKS IN BRASS STRIP PRODUCED BY A THIN LAYER OF DIGLYCEROL TETRANITRATE

Fig. 3. ROTATING DRUM CAMERA TRACE SHOWING THE TWO STAGES IN THE EXPLOSION OF A THIN NITROGLYCERINE LAYER. (ARROW INDICATES DIRECTION OF MOTION OF FILM.)

Fig. 4. METHYL NITRATE TRACE (SLIGHTLY RETOUCHED FOR REPRODUCTION)

is a photograph of a portion of a brass strip beneath which was confined a layer of diglycerol tetranitrate (thickness 0·4 mm.).

The velocities of propagation of the two explosive stages have been measured by means of a rotating drum camera (cf. ref. 4). Typical traces obtained with this apparatus are shown in Figs. 3 and 4. Fig. 3 is a photograph of an explosion in a layer of nitroglycerine (thickness 0·6 mm.) beneath a narrow metal strip, 10 cm. in length; Fig. 4 is a similar photograph obtained with a methyl nitrate layer (thickness 0·1 mm.) confined beneath a small disk. It can be seen from each trace that explosion spreads from the point of initiation *O* with a relatively slow speed—in Fig. 3, *c.* 400 metres/sec. ± 15 per cent. At *P* the faster second stage, *B* (of speed *c.* 1,800 metres/sec. ± 10 per cent in both liquids), is set up *ahead* of the explosion front of the first stage, and simultaneously a 'retonation wave', *R*, is sent back towards the point of initiation[4].

The traces obtained with nitroglycol, methyl nitrate, diglycerol tetranitrate, diethylene glycol dinitrate, and the tetranitromethane/toluene mixtures show that in all these explosives the second stage process (low-velocity detonation) travels at *c.* 1,800 metres/sec. (± 10 per cent). With diglycerol tetranitrate and diethylene glycol dinitrate the first stage travels at about 400 metres/sec. (as in the case of nitroglycerine); but with methyl nitrate (see Fig. 4), nitroglycol and the tetranitromethane toluene mixtures (presumably because of their greater volatility), this process appears to have a somewhat higher velocity—very approximately, 1,000 metres/sec. The 'auto-initiation' of detonation and the simultaneous appearance of the 'retonation wave' are characteristics of all the explosion traces.

This investigation shows clearly that the properties previously reported of nitroglycerine are not peculiar to it but are common to a large number of other liquid explosives, and therefore, in all probability, characteristic of all liquid explosives.

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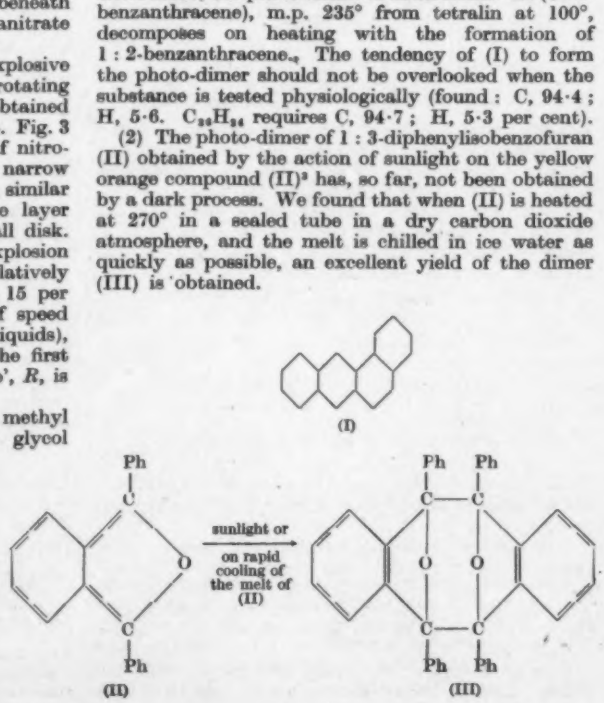
Dimerization Reactions in Sunlight

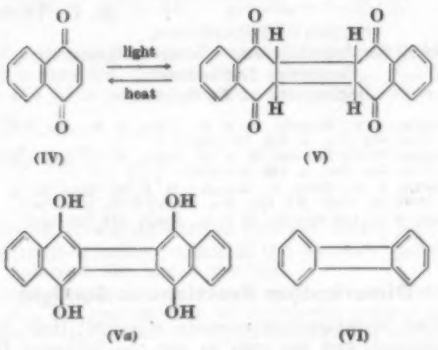
THE investigations recently reported[1] have been continued, and we wish to put the following facts on record. The photo-experiments mentioned below have been carried out in a sealed 'Monax' or 'Pyrex' glass tube (Schlenk tube) in an atmosphere of dry carbon dioxide; in all cases the dark experiments were negative.

(1) Very little is known about the photo-dimerization of carcinogenic[2] hydrocarbons. We found that the carcinogenic 1 : 2-benzanthracene (I) dissolved in benzene very readily forms the difficultly soluble colourless photo-dimer, which is an analogue of dianthracene, the photo-dimer of anthracene. Di-(1 : 2-benzanthracene), m.p. 235° from tetralin at 100°, decomposes on heating with the formation of 1 : 2-benzanthracene. The tendency of (I) to form the photo-dimer should not be overlooked when the substance is tested physiologically (found: C, 94·4; H, 5·6. $C_{36}H_{24}$ requires C, 94·7; H, 5·3 per cent).

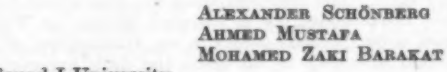
(2) The photo-dimer of 1 : 3-diphenylisobenzofuran (II) obtained by the action of sunlight on the yellow orange compound (II)[3] has, so far, not been obtained by a dark process. We found that when (II) is heated at 270° in a sealed tube in a dry carbon dioxide atmosphere, and the melt is chilled in ice water as quickly as possible, an excellent yield of the dimer (III) is obtained.



(3) When the benzene solution of the yellow α-naphthoquinone (IV) is exposed to sunlight, the photo-dimer (V) is formed, insoluble in aqueous alkali. The substance, colourless crystals m.p. about 244° (decomposition), forms IV on heating (found: C, 75·7; H, 4·1. $C_{20}H_{12}O_4$ requires C, 75·9; H, 3·8 per cent). (V) is of interest as its enol form (Va) is related to the biphenylene (VI) much discussed at present.



(IV) (V)



(Va) (VI)

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Oxidation of Olefins by Chromic Acid

THE oxidation of 2 : 4 : 4-trimethylpentene-1 [α-di*iso*butylene] [I] by chromium tri-oxide dissolved in acetic anhydride yields a neutral oil containing largely 2 : 4 : 4-trimethylpentan-1 : 2-epoxide [II] with smaller amounts of 2 : 2-dimethylpentanone-4 [V], 2 : 4 : 4-trimethylpentanal [III] with 2 : 4 : 4-trimethylpentan-1 : 2-diol [IV] and unsaturated alcohols partly as acetates.

2 : 4 : 4-Trimethylpentene-2 [VI] behaves similarly to give the corresponding epoxide [VII] and other products.

$$\begin{array}{ccccc} Me_3C.CH_2.CHMe.COOH & \leftarrow & Me_3C.CH_2.CHMe.CHO & & \\ \text{[VI]} & & \uparrow & \text{[III]} & \\ Me_3C.CH_2.CMe:CH_2 & \rightarrow & Me_3C.CH_2.CMe.CH_2 & & \\ \text{[I]} & & \text{[II]} \downarrow & \diagdown\diagup\ O & \\ Me_3C.CH_2.CO.CH_3 & \leftarrow & Me_3C.CH_2.C(OH)Me.CH_2(OH) & & \\ \text{[V]} & & \text{[IV]} & & \end{array}$$

The most likely explanation of these observations is that the first stage of the oxidation by chromium tri-oxide in acetic anhydride is the epoxide [II]. If this assumption is accepted and extended to the oxidation of the olefin by chromic acid in aqueous sulphuric acid, this reaction can be considered as dependent on the course of the hydrolysis of the epoxide [II] by the aqueous sulphuric acid, followed by the oxidation of the hydrolysis products by the chromic acid. This permits a satisfactory explanation of the formation of 2 : 4 : 4-trimethylpentanoic acid [IV][1,2] in the oxidation of α-di*iso*butylene by an aqueous sulphuric acid solution of chromic acid, since it is now found that the epoxide [II] on treatment with aqueous sulphuric acid yields not only the glycol [IV] and unsaturated alcohols, but also 2 : 4 : 4-trimethylpentanal [III]. Oxidation of this aldehyde yields the acid [VI], while *neo*pentyl methyl ketone [V] arises from the oxidative fission of the glycol [IV].

Similarly, this hypothesis requires that 2 : 2 : 3 : 3-tetramethylbutanoic acid [IX] should be present in the oxidation products of 2 : 4 : 4-trimethylpentene-2 or of technical di*iso*butylene, which contains about 20 per cent of this olefin. This acid should arise from the oxidation of the aldehyde [VIII], which is known to be formed in small yield from 2 : 4 : 4-trimethylpentan-2 : 3-epoxide [VII] by the action of aqueous sulphuric acid[3].

$$\begin{array}{ccccc} Me_3C.CMe_2.COOH & \leftarrow & Me_3C.CMe_2.CHO & & \\ \text{[IX]} & & \uparrow & \text{[VIII]} & \\ Me_3C.CH:CMe_2 & \rightarrow & Me_3C.CH.CMe_2 & & \\ \text{[VI]} & & \downarrow\ \diagdown\diagup\ O & \text{[VII]} & \\ Me_3C.CHO & \leftarrow & Me_3C.CH(OH).C(OH)Me_2 & & \end{array}$$

A search for this acid in the products of the oxidation of technical di*iso*butylene has now shown that it is indeed present in small amounts.

The anomalies recorded in the literature for the oxidation of olefins by chromic acid in aqueous sulphuric acid find a satisfactory and simple explanation on the basis of the hypothesis indicated here. Thus ethylene is reported to give some acetaldehyde and acetic acid[4,5], di*neo*pentylethylene ($C_{12}H_{24}$) gives some di*neo*pentylacetic acid, $C_{12}H_{24}O_2$ [6]; a small yield of an octanoic acid from octene is reported[7]. In the same category must be included the formation of trimethylacetic acid from tetramethylethylene[8].

On this hypothesis one may also predict, from a knowledge of the behaviour of the epoxides in diluted sulphuric acid, what olefins should yield abnormal products on oxidation with chromic acid in aqueous sulphuric acid.

A full account of this work will be published elsewhere, and its extension on the lines indicated in this communication is in progress. Acknowledgment is made of the financial assistance afforded by the Institute of Petroleum, and also to Prof. F. H. Garner for providing facilities and accommodation for this work.

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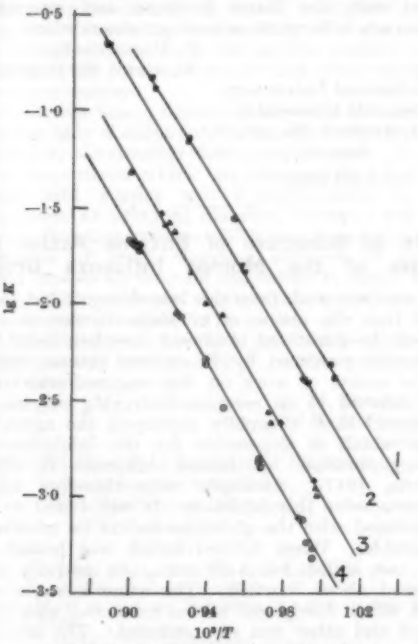
The C—H Bond Energy in Toluene and Xylenes

THE pyrolysis of toluene and of the three xylenes has been investigated by a flow method in a silica reaction vessel with a technique permitting the measurement of the rate of the reaction for decompositions ranging from 0·01 per cent up to a few per cent. The reactions were shown to be homogeneous gas reactions of the first order, the first-order constant remaining the same when the time of contact and the pressure of the hydrocarbons were varied.

The gaseous products were hydrogen and methane. No ethane or ethylene was observed except for slight amounts in the case of *ortho*-xylene, and the ratio of hydrogen to methane was the same under all conditions, being 1·5 for toluene and *meta*-xylene, 2·0 for *para*-xylene and 1·1 for *ortho*-xylene. In addition to the gaseous products, dibenzyl was formed in the pyrolysis of toluene, and its homologue in the pyrolysis of *meta*-xylene.



○, toluene; △, *meta*-xylene; ▽, *para*-xylene; □, *ortho*-xylene

In the graph lg K is plotted against $1/T$ for the four hydrocarbons investigated. These graphs show that all the above-mentioned reactions have an energy of activation of about 76 ± 2 kcal. and frequency factors of the order 10^{13}, which corresponds to a true unimolecular reaction[1].

The experimental evidence shows clearly that the first step in the pyrolysis of these hydrocarbons is the decomposition into benzyl or xylyl radicals and hydrogen atoms, according to equation (1).

$$C_6H_5CH_3 \rightarrow C_6H_5CH_2 + H, \qquad (1)$$

which is followed by the fast reactions (2), (3) and (4)

$$C_6H_5.CH_3 + H \rightarrow C_6H_5.CH_2 + H_2 \qquad (2)$$

and
$$\begin{cases} C_6H_5.CH_3 + H \rightarrow C_6H_6 + CH_3 & (3a) \\ C_6H_5CH_3 + CH_3 \rightarrow C_6H_5CH_2 + CH_4 & (3b) \end{cases}$$

or
$$\begin{cases} C_6H_5.CH_3 + H \rightarrow C_6H_5 + CH_4 & (4a) \\ C_6H_5.CH_3 + C_6H_5 \rightarrow C_6H_6 + C_6H_5.CH_2 & (4b) \end{cases}$$

and finally by the dimerization of benzyl radicals, leading to formation of dibenzyl:

$$2C_6H_5.CH_2 \rightarrow C_6H_5.CH_2.CH_2.C_6H_5. \qquad (5)$$

This mechanism accounts for the unimolecular reaction and for the observed products of the decomposition, and it gives the ratio of $(H_2 + CH_4)$ to dibenzyl as one mol. per mol., in agreement with observation.

From considerations which will be published later we conclude that the following are the best values for the energies of activation and frequency factors:

Hydrocarbon	Energy of activation	Frequency factor
Toluene	77·5 kcal.	2×10^{13}
Meta-xylene	77·5 kcal.	4×10^{13}
Para-xylene	75·0 kcal.	4×10^{13}
Ortho-xylene	74·0 kcal.	4×10^{13}

The frequency factor for xylenes (twice as great as for toluene) reflects the fact that the probability of reaching the transition state is twice as great as in toluene, owing to the presence of two methyl groups in these hydrocarbons. Thus the observed increase in the rate of decomposition of *meta*-xylene compared with that of toluene is ascribed to the increase of frequency factor only, whereas the further increase of the rate of decomposition observed in the case of *para*- and *ortho*-xylenes is taken to indicate a slight decrease in the energy of activation.

We may assume that the observed energy of activation corresponds to the C—H bond-strength, for which, therefore, we obtain in the cases of toluene and *meta*-xylene 77·5 kcal., and in the cases of *para*-xylene and *ortho*-xylene 75 kcal. and 74 kcal., respectively. Taking the C—H bond-strength in methane[2] to be 102 kcal., there is a reduction by 24·5 kcal. for the benzyl and *meta*-xylyl radicals, 27 kcal. for the *para*-xylyl radical and 28 kcal. for the *ortho*-xylyl radical. We may assume that these values represent the resonance energies of the radicals formed. They are noticeably higher than the figure of 16 kcal. obtained previously for toluene by theoretical calculations[3].

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Computation of the Free Energy of α-Ketoglutarate and Pyruvate from Constants of the Transamination Process

FROM the knowledge of the equilibrium constants K_1 and K_2 of transamination systems:

Glutamic acid + pyruvic acid ⇌ α-ketoglutaric acid + alanine (1)

Glutamic acid + oxaloacetic acid ⇌ α-ketoglutaric acid + aspartic acid (2)

it is possible to determine the free energies of the bivalent ketoglutarate ion and the monovalent

pyruvate ion, when the free energies of the four other components participating in the reactions are known.

Under the experimental conditions (pH = 7·5; temp. = 25°) the components are dissociated as follows: Monovalent anions of glutamic acid ($GA^{\pm}$), aspartic acid ($AA^{\pm}$) and pyruvic acid (PA^{-}), bivalent anions of oxaloacetic acid ($OAA^{=}$) and α-ketoglutaric acid ($KGA^{=}$), and neutral alanine ($A^{\pm}$). The relationship between the free energies ΔF_1 and ΔF_2 of the two reactions and the components involved here is expressed in the equations:

$$\Delta F_1 = \Delta F_{KGA^{=}} + \Delta F_{A^{\pm}} - \Delta F_{GA^{\pm}} - \Delta F_{PA^{-}} \quad (3)$$

$$\Delta F_2 = \Delta F_{KGA^{=}} + \Delta F_{AA^{\pm}} - \Delta F_{GA^{\pm}} - \Delta F_{OAA^{=}} \quad (4)$$

From the degree of reaction in the equilibrium state (determined as previously described[1]), we obtain $K_1 = 2{\cdot}25$ and $K_2 = 5{\cdot}44$. By insertion in the equation $\Delta F = -RT \cdot \log_e K$ we obtain $\Delta F_1 = -0{\cdot}48$ and $\Delta F_2 = -1{\cdot}0$ kcal. at 25°. Further, $\Delta F_{GA^{\pm}} = -162{\cdot}85$, $\Delta F_{AA^{\pm}} = -166{\cdot}40$, $\Delta F_{A^{\pm}} = -89{\cdot}20$ kcal.[2] and $\Delta F_{OAA^{=}} = -184{\cdot}21$ kcal.[3]. Then, inserting these values in (3) and (4), the equations yield the results:

$\Delta F_{KGA^{=}} = -181{\cdot}66$ kcal. and $\Delta F_{PA^{-}} = -107{\cdot}53$ kcal.

The free energy of pyruvate is in a rather good agreement with that determined by Borsook (cf. ref. 3), who finds $\Delta F_{PA^{-}} = -106{\cdot}46$ kcal.

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A Microbiological Method of Standardizing Liver Extracts

The insect *Cicadella viridis* has two symbiotic bacteria, one producing a green pigment, the other *B. carotens*. The red bacterium is a diagenete[1], or dysgonic commensal, of the other partner. However, a pure culture has been grown on media with liver extracts. It thus appeared that if the organism is dependent upon a metabolite present in liver extracts, its quantity present in the latter can be judged by the growth of this organism. For this purpose a basal medium was prepared with the following composition: glucose 2 per cent; peptone 1 per cent; citric acid 0·2 per cent; alkaline sodium phosphate 0·4 per cent; sodium chloride 0·2 per cent; magnesium sulphate 0·1 per cent. Only upon the addition of liver extracts would the bacterium grow. Growth was apparent after 72 hours and was suitable for comparison after seven days.

The range of pH was found to be between 6·6 and 7·6. On the alkaline side the bacterium produced acidity which changed the medium towards neutrality. The optimum pH was found to be 7, and our experiments were carried out at this pH.

Liver extracts were made in the following manner. 100 gm. of sheep or goat liver were minced, mixed with 70 c.c. water, placed in a flask and kept in a steam sterilizer for 1½ hours. For every 100 c.c. of the final liquid medium, 100 gm., 200 gm., 300 gm. or 400 gm. of liver were used. Media with such concentrations of liver extracts were inoculated with the red bacterium and growth compared after seven days. The difference was clear enough to be judged qualitatively. This study is being developed to give quantitative results, as it promises to be a useful microbiological method of standardizing liver extracts. Naturally, it is also proposed to compare it with the usual method of assaying liver extracts clinically.

The metabolite present in liver extracts is heat-labile; for the bacterium shows no growth upon liver extracts autoclaved for 6 hours at 15 lb. pressure. Further, liver extracts, shaken with fuller's earth, filtered and added to the basal medium, show a meagre growth; a similar adsorption takes place with active charcoal. Kaolin, on the contrary, does not adsorb it. By removing the metabolite from fuller's earth and from active charcoal it is hoped to obtain it in a concentrated form and thus study its chemical nature. A culture of the bacterium has been deposited with the Lister Institute, and interested workers are welcome to extend our observations.

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[1] *Curr. Sci.*, **9**, 495 (1940).

Mucin as Substrate of Enzyme Action by Viruses of the Mumps Influenza Group

In previous work from this laboratory it has been found that the action of influenza viruses on red cells can be paralleled in almost complete detail by an enzyme produced by *V. cholerae*[1] (Stone, 1947). In the course of work on this enzyme, which we have referred to as receptor-destroying enzyme, it was found that it rapidly destroyed the agent in serum which is responsible for the inhibition of hæmagglutination by heated influenza *B* virus[2] (Francis, 1947). Attempts were therefore made to characterize this inhibitor. It was found to be precipitated with the globulins and to be relatively heat-stable. When diluted serum was heated to 70° C. or boiled for 5–10 min., its activity was increased about fourfold. The same increase was found when 'hardyized' serum extracted with cold alcohol and ether was reconstituted. The activity of the semi-purified material was destroyed by trypsin and by dilute (M/4,000) solutions of potassium periodate.

The suggestion arising from this result that a polysaccharide-protein complex might be concerned led to our testing certain mucin preparations which were being used in other work. It was found that dilute solutions of glandular mucin had all the essential properties of the 'Francis inhibitor' in serum. A crude preparation of the semi-solid viscous-elastic mucus from a so-called pseudomucinous cyst of the ovary was active as an inhibitor to a dilution of 1 in 500,000, the average titre of serum by the same technique being about 1 : 1,000. In view of the use by Morgan and van Heyningen[3] of such cysts as a source of blood-group substance, samples of purified *A* and *O* substance kindly given to us by Dr. W. T. J. Morgan were tested as inhibitors. The *O* substance was active to a dilution of 1 : 1,200,000

as an inhibitor of haemagglutination by heated influenza *B* virus. The *A* substance was much weaker with a titre of 1 : 20,000. The activity of both substances as inhibitors was destroyed by incubation with the receptor-destroying enzyme, but the *A* substance had lost none of its ability to block agglutination of human Group *Al* cells by a specific anti-*A* serum also provided by Dr. Morgan. No suitable anti-*O* serum was available for corresponding tests with the *O* substance.

Anderson (unpublished) has shown that unheated influenza viruses can produce significant destruction of the 'Francis inhibitor' in serum. Further, the receptors on the red cell which react with viruses of the group are destroyed like the inhibitor by the receptor-destroying enzyme and potassium periodate and not by any of a large number of other enzymes and chemical reagents that we have tested. This evidence seems adequate to characterize the substrate of the virus-enzyme as a mucin, and in all probability the same mucin as is responsible for the *A B O* blood group specificity. It should be stressed, however, that the serological specificity of the mucin in the red-cell surface, as in the soluble purified form, is not modified by the action of virus or the receptor-destroying enzyme.

Connective tissue mucin in the form of synovial fluid has only a slight inhibitory effect which is not affected by the receptor-destroying enzyme. In view of the importance which has been ascribed to hyaluronic acid mucins and hyaluronidases in the phenomena of bacterial invasion, it seems not out of place that those viruses which are characteristically pathogens of mucus-secreting surfaces or glands should possess an enzyme equivalent in many ways to the hyaluronidases of various pathogenic bacteria, but acting on glandular type mucin.

A full account of this work and of related studies on the enzymes produced by *V. cholerae* will be published elsewhere.

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July 17.

[1] Stone, J. D., *Aust. J. Exp. Biol. and Med. Sci.*, in the press.
[2] Francis, T., *J. Exp. Med.*, **85**, 1 (1947).
[3] Morgan, W. T. J., and van Heyningen, R., *Brit. J. Exp. Path.*, **25**, 5 (1944).

Control of Banana Wilt Disease

Some years ago I reported in these columns an unusually interesting and important field experiment on the control of Panama (wilt) disease of bananas (*Fusarium oxysporum cubense*), which I had seen while travelling in Honduras[1]. This consisted in flood-fallowing an area of about a hundred acres which had gone out of cultivation because of wilt disease. The area was empoldered (contained within earth embankments) and divided into sections, each of which was being kept submerged for a different period of time. This experiment was based on the observation that soil fungi, such as *F. oxysporum*, require oxygen to live, and that, when highly infected soil was submerged for one month under two feet of water, no living *Fusarium* could be found in it. At that time I wrote: "The outcome of this experiment will be awaited with the greatest interest by all associated with the extensive alluvial banana lands of Central America". Already, at that time (1940), it had been found that in new land, built up by the sedimentation of controlled flood water, and therefore subjected to several inundations, the incidence of wilt disease was negligible.

Recently I had news of the experiment from a scientific correspondent, Dr. V. C. Dunlap, to whom I now make acknowledgment. Areas originally flooded for six, twelve and eighteen months have been producing fruit for nearly six years, and it is considered that several years of good production still lie ahead. Scattered cases of wilt disease did appear after ten to eighteen months, but the subsequent spread of the disease was slow. As in many good soils, a mat or stool may show disease in one plant while all the other plants apparently remain unaffected for two or three years. It is considered improbable that the method of flood-fallowing will ever be successful in acid soils (in which plants succumb readily and in which the fungus may spread with great rapidity), but the system is being extended to other areas considered to be suitable.

Much credit is due to the officers of the United Fruit Co. for their enterprising experimentation on a large scale.

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Aug. 6.

[1] *Nature*, **147**, 313 (1941).

A Pitfall in Correlation Theory

It has often been assumed that when two quantities x and y are normally distributed by themselves, their joint distribution is given by the bivariate normal surface

$$f(x,y) = \frac{1}{2\pi\sqrt{1-\rho^2}} \exp\left\{ -\frac{1}{2(1-\rho^2)} (x^2 - 2\rho xy + y^2) \right\},$$

x,y being expressed in standard units and ρ being their correlation coefficient. Further, for $\rho > 0$, it is supposed that the two quantities x and y increase or decrease together, while for $\rho < 0$, one quantity increases as the other decreases. I give below an example to show that both the above assumptions are ill-founded.

Suppose y is functionally related to x by a relation expressed in parametric form as

$$\left.\begin{aligned} x &= \quad \varphi^{-1}(t) && \text{for } 0 < t < 1 \\ y &= -\varphi^{-1}(t + \tfrac{1}{2}) && ,, \quad 0 \leqslant t < \tfrac{1}{2} \\ &= -\varphi^{-1}(t - \tfrac{1}{2}) && ,, \quad \tfrac{1}{2} < t \leqslant 1 \end{aligned}\right\} \qquad (1)$$

where $\varphi(x) = \dfrac{1}{\sqrt{2\pi}} \displaystyle\int_{-\infty}^{x} \exp(-u^2/2)\, du.$

Then the graph of y against x resembles the two branches of the hyperbola $xy =$ constant, and if now x is normally distributed with mean 0 and standard deviation 1, it can be shown that y is normally distributed with mean 0 and standard deviation 1. The correlation coefficient between x and y is $+ 0{\cdot}3225$, which is positive even though y increases as x decreases and *vice versa*. It can be shown that the joint distribution of x and y is given by

$$f(x,y) = \frac{1}{\sqrt{2\pi}} \cdot \frac{1}{\sqrt{e^x + e^y}},$$

defined for values of x and y lying on the curve given by equations (1). The surface is singular and clearly not normal.

By considering the joint distribution of x and $y + e$, where e is a normally distributed 'error', independent of x and y, we can obtain examples, with the properties indicated above, in which the joint distribution is non-singular.

The example bears on the use of tetrachoric r as a 'metrical' measure of association between qualitative characters. What is assumed here is not merely that there exist separate metrical scales giving normal distribution separately to each of the hypothetical quantities supposed to underlie the given qualities. What is required is that the joint distribution of the hypothetical quantities be normal—a much stronger assumption.

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The Vienna Academy of Sciences

In his article on the Vienna Academy of Sciences, Dr. R. W. Lawson[1] refers to the Biologische Versuchsanstalt and its distinguished directors. He does not mention E. Steinach, head of the Physiology Department and whom many biologists regard as the founder of modern endocrinology. Pincus[2] and Sherrington[3] refer to his work carried out during the long period 1898–1940. Steinach served as director from 1910 until 1938, when Austrian S.A. men invaded his estate and forced him to accept refuge in Switzerland, where he died about two years ago.

Steinach shared the great financial sacrifices that the directors had to make from their own pockets to maintain their laboratories. In the early twenties, inflation prevented the directors from continuing their donations, and the Academy lacking funds the Biologische Versuchsanstalt was about to close down. Just in time, however, the work done in Steinach's department attracted the interest of the Schering, A.G. A contract was arranged which enabled the Physiology Department to carry on, and on a much larger scale, the whole institute benefiting from the funds received.

The other directors referred to, H. Przibram and L. von Portheim, are now also dead, and I feel sure that they would be the very first to write this letter if they were still alive.

O. Peczenik

Sunbury-on-Thames,
Middlesex.

[1] Lawson, R. W., *Nature*, **159**, 831 (1947).
[2] Pincus, G., "Recent Progress in Hormone Research". *Proceedings of the Laurentian Hormone Conference*. (Academic Press, Inc., New York, 1947.)
[3] Sherrington, C., "The Integrative Action of the Nervous System" (Cambridge University Press, 1947).

I can assure Dr. Peczenik that I had no intention of doing an injustice to any prominent member of the Vienna Biologische Versuchsanstalt in my recent article on the Vienna Academy of Sciences, and I am interested to learn of E. Steinach's valuable contributions on the physiological side of that institution's work during 1910–38.

As a physicist, I had no direct contact with the work of the "Vivarium" during my six years in Vienna, and although I had a slight acquaintance with Hans Przibram, I was dependent for personal information primarily on an article by E. Broda and A. Stock[1], who speak of the Versuchsanstalt (founded in 1901) as "the unique creation of Professor Hans Przibram". In the same publication (p. 10), Przibram's brother Karl writes of it as having been "founded conjointly with L. Portheim and W. Figdor by my late brother, Hans Przibram". "It was my brother's aim to make the Institute a centre not only of experimental, but also of 'quantitative' biology, and I hope this trend of research may be continued there, in memory of him who died a victim of Nazi barbarism." In his obituary notice on Leopold von Portheim, C. R. Metcalfe[2] refers to the same three biologists as the founders of the Biologische Versuchsanstalt.

Perhaps I may be allowed to use this opportunity to correct a slight error in my article on the Vienna Academy. I had been given to understand that the physicist Karl Przibram had returned to work in the Vienna Radium Institute after the War. In a letter I have received from him recently, however, he informs me that he is now director of the II. Physikalisches Institut of the University of Vienna. Prof. Karl Przibram is a worthy successor in the train of eminent physicists who have held that post—Franz Exner, Gustav Jäger, and Egon von Schweidler.

Robert W. Lawson

[1] See p. 14 and p. 20 of the pamphlet entitled "Science in Austria", published in November 1945 by the Association of Austrian Engineers, Chemists, and Scientific Workers in Great Britain, London, W.2.
[2] *Nature*, **159**, 835 (1947)

Text-book Organic Chemistry

We illustrate below by two examples certain elementary errors which have become imbedded in many text-books, with the result that some of the first facts of organic chemistry are being incorrectly presented to each succeeding group of students.

(1) The reaction between ethyl alcoholic potassium hydroxide and ethyl bromide, in fact, yields *ether*. Even if this be not generally known, the usual statement that it yields ethylene is inexcusable, for no one has ever shown that ethylene can thus be prepared in substantial yield[1].

(2) The reaction between nitrous acid and methylamine yields mainly *methyl nitrite*. Being a gas, it goes away with the nitrogen, and hence has generally not been recognized; but that cannot justify the statement, for which no authority exists, that the main product is methyl alcohol. (Neither is it true that *no* methyl alcohol is formed, or that methyl ether is the main product[2].)

It seems that the text-books have started a chain-reaction. They teach these stories to the students, whose examination papers by sheer repetition help to establish the said stories in the minds of the teachers, who then teach them to the next generation of students, whose examination papers . . . This letter is intended as a chain-breaker.

A. T. Austin
E. D. Hughes
C. K. Ingold

Sir William Ramsay and Ralph Forster Laboratories,
University College, London, W.C.1.
June 3.

[1] Cf. Hughes, Ingold, Masterman and MacNulty, *J. Chem. Soc.*, 899 (1940).
[2] Details of this reaction will be given in a forthcoming paper.

CORRELATION BETWEEN PENICILLIN RESISTANCE AND ASSIMILATION AFFINITY IN *STAPHYLOCOCCUS AUREUS*

By Dr. ERNEST F. GALE

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GRAM-POSITIVE cocci possess the ability to assimilate certain amino-acids and to concentrate them in the free state within the internal environment[1,2]. The level of free amino-acid attained within the cell is determined by the balance between the rate at which the amino-acid is assimilated from the external environment and the rate at which it is metabolized within the cell[3]. If the assimilation process is impaired, then the level of free amino-acid within the cell will fall as metabolism continues; conversely, if the internal metabolism is inhibited, then the level will rise to a saturation value. Studies on the assimilation and concentration of glutamic acid by Gram-positive cocci have shown that the migration across the cell-wall requires energy which can be supplied by glycolysis[1], and that the free amino-acid in the internal environment acts as a source of glutamic acid for protein synthesis in the growing cell[4], and also undergoes some other form of metabolism which is inhibited by triphenylmethane dyes[2]. When the cells are grown in penicillin, the assimilatory processes become impaired, with the result that glutamic acid and glutamine can no longer be assimilated from the external environment, and, since the internal metabolic processes are not affected, the level of free glutamic acid within the cell falls until protein synthesis, and consequently growth, can no longer take place[5,6].

It has been shown that the penicillin concentrations necessary to block glutamic acid assimilation are of the same order as those necessary to prevent growth of the organisms. When resistant organisms are studied, the same correlation is found—if one organism is ten times more resistant than another, then ten times as much penicillin is required to block glutamic acid assimilation in the former as compared with the latter. The following series of estimations were carried out in an attempt to correlate the assimilation process with penicillin sensitivity. First, the maximum level of free glutamic acid attained within the cell when this is standing in a constant high external concentration (200 μl./ml.) has been determined for a series of organisms of different penicillin sensitivity. In order to determine this value, it is necessary to inhibit the internal metabolism of glutamic acid. Accordingly the experiments were performed with washed cells (in which protein synthesis does not occur[4]) in the presence of that concentration of crystal violet giving optimal inhibition of intracellular metabolism[2] (1 μgm./mgm. cells for *Staph. aureus*); other experimental details were as previously described[1,2]. The accompanying table shows that there is no relation between the concentration of glutamic acid within the cell and its sensitivity to penicillin. The organism *Staph. aureus* 6773 was trained by serial subcultivation in increasing concentrations of penicillin to a resistance of 2,000 Oxford units/ml., and the internal concentration achieved in the cells is not significantly altered by the training process.

CONCENTRATION OF FREE GLUTAMIC ACID IN INTERNAL ENVIRONMENT OF CELLS OF DIFFERENT PENICILLIN SENSITIVITY

External medium: salt mixture; 1 per cent glucose; 200 μl. glutamic acid/ml.; crystal violet in minimum concentration necessary to inhibit internal metabolism. Internal concentration expressed as μl. glutamic acid in the internal environment of 100 mgm. dry weight of cells. All cells harvested from 6-hr. culture at 37°.

Organism	Strain	Penicillin test		Internal concentration of glutamic acid (μl./100 mgm.)
		Growth units/ml.	No growth units/ml.	
Staph. aureus	563	0·02	0·04	1165
B. subtilis	Stock	0·04	0·06	26
Staph. aureus	*D*	0·06	0·08	660
Strep. fæcalis	*ST*	6·0	8·0	534
Staph. aureus	6773	15·0	20·0	825
" "	6773	60	70	750
" "	6773	250	300	740
" "	6773	2000	4000	705

The internal concentration of glutamic acid at equilibrium depends to a certain extent upon the concentration of that amino-acid in the external environment[1]. By the methods previously described, it has not been possible to determine accurately the relation between internal and external concentrations when the latter is small, but this has now been done by carrying out the equilibration in the presence of crystal violet to prevent metabolism, and by suspension of the washed organisms in a volume of solution (1 mgm. organism in 5 ml.) sufficiently large to render insignificant any alterations of the external concentration due to traces of glutamic acid carried down on the surface of the cells, etc. Fig. 1 shows curves obtained in this way for strains of *Staph. aureus* and *Strep. fæcalis*, and it can be seen that the internal concentration falls very rapidly when the external concentration falls below a certain value in each case. The 'assimilation constant' is defined as that value of the external concentration which gives rise to an internal concentration equal to half the maximum attained at saturation (taken as the internal value corresponding to an external concentration of 200 μl./ml.). The reciprocal of the assimilation constant can be taken as a measure of the affinity of the assimilation process of the organism towards glutamic acid. From Fig. 1 it can be seen that the assimilation constant of the strain of *Staph. aureus* tested is 2–3 μl./ml., while that for the strain of *Strep. fæcalis* is 6–7 μl./ml.

The assimilation constants of the organisms listed in the table have been determined in this way. In each case the organisms were grown for 6 hr. at

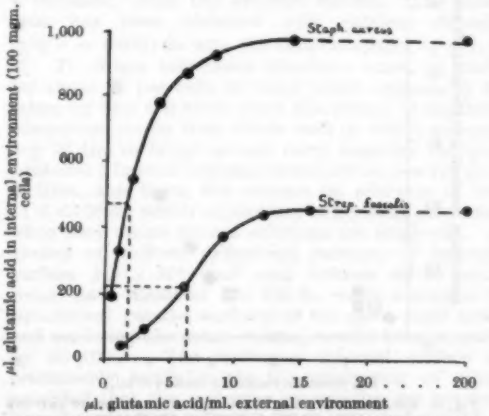

Fig. 1. DEPENDENCE OF INTERNAL GLUTAMATE CONCENTRATION ON EXTERNAL CONCENTRATION

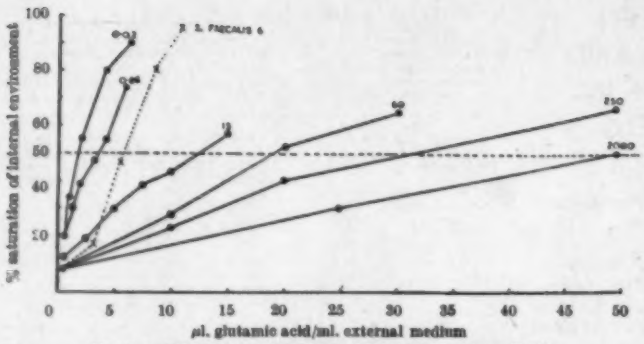

Fig. 2. ASSIMILATION AFFINITIES (GLUTAMIC ACID) OF *Staph. aureus* OF DIFFERING PENICILLIN SENSITIVITIES

37° C. in the 'deficient' medium previously described[1], made into washed suspension, and incubated for 90 min. at 37° C. in the presence of glucose, crystal violet and known concentrations of glutamic acid. Fig. 2 shows the affinity curves so obtained for various strains of *Staph. aureus*. Since the saturation-level attained within the cell for an external concentration of 200 μl./ml. varies with the organism (see table), the ordinates express the internal concentration in each case as a percentage of the saturation-level. The penicillin sensitivity of each organism is given at the top of each curve. Staphylococci sensitive to 0·04–0·06 units penicillin/ml. have assimilation constants of the order 2–4 μl./ml., while organisms which are more resistant to penicillin have lower affinities for glutamic acid assimilation. The organism originally resistant to 15 units penicillin/ml. was trained until it would grow in 2,000 units/ml.; its affinity for glutamic acid was tested at stages when it was resistant to 60, 250, and 2,000 units/ml. respectively, and the curves show how the assimilation constant increased during the training process. In most cases the actual value of the assimilation constant must be obtained by extrapolation at the zero point, and Fig. 3 shows the relation between the constant and the logarithm of the penicillin resistance. The assimilation constants obtained for a sensitive *B. subtilis* and for a resistant *Strep. faecalis* fall into line with those obtained with the series of *Staph. aureus* strains.

These experiments show clearly that there is a relation between the assimilation process towards glutamic acid and the penicillin sensitivity of the cell concerned, and that the more resistant the cells become, the less efficient are their assimilatory processes. These variations demonstrated for glutamic acid may be symptomatic of a general change in the assimilatory properties of the cells. It is possible that if the penicillin resistance were pushed still higher, then the organism might have to change the character of its metabolism in order to continue to grow; such a change has been reported by Bellamy and Klimek[7], although full details are not yet available.

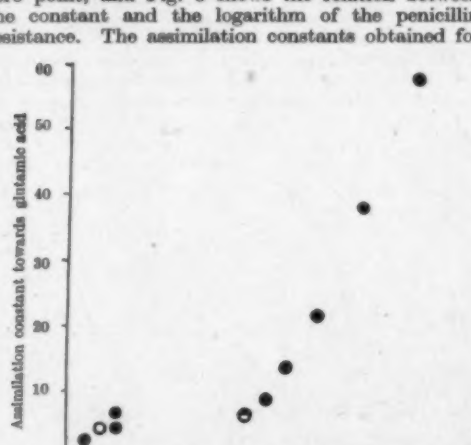

Fig. 3. RELATION BETWEEN THE ASSIMILATION CONSTANT AND THE LOGARITHM OF THE PENICILLIN RESISTANCE
● *Staph. aureus*; ○, *B. subtilis*; ⊖, *Strep. faecalis*

[1] Gale, E. F., *J. Gen. Microbiol.*, **1**, 53 (1947).
[2] Taylor, E. S., *J. Gen. Microbiol.*, **1**, 86 (1947).
[3] Gale, E. F., and Mitchell, P. D., *J. Gen. Microbiol.*, **1** (Sept., 1947).
[4] Gale, E. F., *J. Gen. Microbiol.*, **1** (Sept., 1947).
[5] Gale, E. F., and Taylor, E. S., *Nature*, **158**, 676 (1946).
[6] Gale, E. F., and Taylor, E. S., *J. Gen. Microbiol.*, **1** (Sept., 1947).
[7] Bellamy, W. D., and Klimek, J. W., *J. Bact.*, **53**, 374 (1947).

CALCULATION OF SURFACE AREAS FROM MEASUREMENTS OF NEGATIVE ADSORPTION

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WHERE a charged surface is in contact with a solution of electrolyte, the ions of opposite charge are attracted to the surface while those of like charge are repelled from it. I considered that it would be possible to compute the negative adsorption of the repelled ions from the basic assumptions of Gouy's theory of the diffuse electric double layer, and therefore invited Mr. M. H. Quenouille to tackle the mathematical difficulties involved. Complete solutions have now been obtained for electrolytes in which the ions have valency ratios 1 : 2, 1 : 1, and 2 : 1, and a full account of this work will be submitted for publication shortly.

Guided by these results, I have obtained, for the general case where all the attracted ions have valency ν, and all the repelled ions have valency ν/p, the equation

$$\frac{\Gamma_-}{n} = \frac{q}{\sqrt{\nu\beta n}} - \frac{4}{\nu\beta\Gamma},$$

which, although it is only an approximate relationship, is nevertheless sufficiently accurate in practice, provided that the second term is less than one fifth of the first. Γ_- is the negative adsorption of the repelled ions per unit area (milliequivalents/cm.^{2}), and n is the normality of the 'external' solution (milliequivalents/cm.^{3}), so that Γ_-/n is a distance (cm.), q is a factor which depends on the valency ratio, p, and is tabulated below, the values given to four decimal places having been calculated, and the rest obtained from them by a graphical method. β stands for $8\pi F^2/\epsilon RT$, which depends principally on the dielectric constant, ϵ, and has the magnitude

$1{\cdot}06 \times 10^{16}$ cm./milliequivalent for water at 25° C. Γ is the surface charge (milliequivalents/cm.²). The equation is subject to the further limitations that n is small enough for the electrolyte solution to be treated as ideal, and that the surfaces are substantially flat and widely spaced.

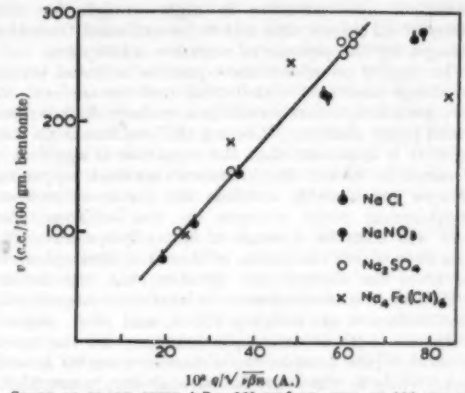
Valency ratio p	Factor q
0	3·1416 (π)
1/7	2·91
1/6	2·88
1/5	2·83
1/4	2·76
1/3	2·65
1/2	2·4495 ($\sqrt{6}$)
1	2·0000
3/2	1·69
2	1·4641 ($\sqrt{11}$–2)
3	1·16
4	0·96

This equation is peculiarly suitable for comparison with experiment, because the first term depends on the concentration but *not* on the magnitude of the surface charge (beyond the general condition that Γ must be large enough for the first to be the main term), while the second term depends on the surface charge but *not* on the concentration. The results of experimental determinations are conveniently expressed by the quantity, v, obtained by dividing the negative adsorption expressed in milliequivalents per 100 gm. of sorbate by the normality of the solution. By plotting v against $q/\sqrt{\nu\beta n}$, a straight line will be obtained between certain limits of concentration, if the necessary conditions are fulfilled, its slope giving the surface area per 100 gm. of sorbate. The upper limit of concentration is set both by the need for the first to be the main term, and by the serious departure from ideal solution at high concentrations. The lower limit is reached when $q/\sqrt{\nu\beta n}$ becomes comparable with the distance between neighbouring surfaces, or with the radii of curvature of the surfaces. Mr. Quenouille has analysed the case for two parallel plane surfaces in a 1 : 1 electrolyte, and from his results it can be seen that departure is unimportant until $q/\sqrt{\nu\beta n}$ reaches one quarter of the distance separating the surfaces.

To illustrate the application of this equation, use has been made of measurements by Mattson[1] on the partition of anions of sodium salts between aqueous sodium bentonite and water. As will be seen from the accompanying figure, the points for sodium sulphate fall remarkably well on a straight line. The area per 100 gm. of bentonite works out at $4{\cdot}7 \times 10^8$ cm.². Assuming the particles to be thin plates, their average thickness is 18 A. X-ray analysis gives 10 A. as the thickness of each layer of the lattice of montmorillonite. A 'complete dispersion' of 100 gm. of pure montmorillonite (density 2·5) should, therefore, have a surface area of 8×10^8 cm.². It will be of great interest to discover whether such a 'complete dispersion' can be achieved.

Mattson states that the bentonite was slightly contaminated with sulphate, and that the results for the lowest concentrations of chloride and nitrate may have been affected. The remaining points for these anions lie very close to the sulphate line. The close agreement of slope is a useful check on the dependence of q on p. Mattson experienced difficulties in making the measurements with ferrocyanide, but it will be seen that the point for the highest concentration falls in with those for sulphate and chloride.

From the equation it seems that the intercept of the straight line on the axis of the abscissa should



SLOPE OF GRAPH GIVES $4{\cdot}7 \times 10^8$ CM.² AS AREA OF 100 GM. OF BENTONITE (DATA OF S. MATTSON)

give $4/\nu\beta\Gamma$. For montmorillonite, Γ is about 10^{-7} milliequivalents/cm.², giving a calculated intercept of 4 A. The intercept is approximately of this magnitude, but quantitative agreement is not to be expected. A constant varying in magnitude from one electrolyte to another should be added to the equation to allow for the departure from ideal solution close to the surface. This will not interfere with the calculation of surface area from the slope of the graph, but will prevent us from obtaining Γ from the intercept.

In the case of a particulate suspension the state of dispersion may itself depend on electrolyte concentration. If this were to cause a variation in effective surface area with electrolyte concentration, the plot would not give a straight line and the area could not be found. With this possibility in mind, I asked Mr. O. Talibuddin to study negative adsorption in jute fibre, since it does not seem possible for the internal surface of a fibre to vary with salt concentration. Jute was chosen because it is known to contain a fairly high content of carboxyl groups, and it was hoped that $4/\nu\beta\Gamma$ would be small enough for the equation to be applied. This hope has been fulfilled. Several samples of jute fibre have been examined and found to have surface areas in the neighbourhood of $1{\cdot}6 \times 10^8$ cm.² per 100 gm. of dry fibre (160 square metres per gram), which is roughly a thousand times the external surface. The same area has been obtained with calcium chloride ($q/\sqrt{\nu} = 1{\cdot}035$) as with the alkali chlorides ($q/\sqrt{\nu} = 2$). To obtain this result allowance must be made for about 11 per cent of water which appears to be taken up into the solid, since this extent of negative adsorption occurs from dilute acid in which scarcely any of the carboxyl groups carry negative charges. v reaches a limit of between 40 and 80 c.c. per 100 gm. of fibre, this being the volume (in addition to the 11 c.c.) from which anions are completely excluded when very dilute neutral solutions are employed. A system of uniform cylindrical passages of internal surface $1{\cdot}6 \times 10^8$ cm.² and volume 40–80 cm.³ would have diameter 100–200 A., while a system of equidistant parallel surfaces of the same total area, and enclosing the same volume, would be separated by 50–100 A. The enormous internal surface is presumably available for the adsorption of dyes, provided that the molecules or micelles are not too large to pass freely along the passages, and provided also, as Neale[2] has recently pointed out, that the

electrolyte concentration is high enough for the anions of an anionic dye not to be excluded from the passages by the process of negative adsorption.

The theory on which the equation is based treats the charge as evenly distributed over the surface. A more accurate picture would be a uniform distribution of unit point charges. Viewing the problem from this angle, it is apparent that the equation is applicable to cases in which the distance between opposing surfaces considerably exceeds the distance between neighbouring point charges on the surfaces; for there will then be a range of electrolyte concentrations over which the radius of the ionic atmosphere is less than the former and greater than the latter. In Mattson's measurements on bentonite suspension, these distances are roughly 500 A. and 10 A. respectively, so there is an ample margin. In the most favourable jute sample, the distances were 90 A. and 12 A., while in the least favourable they were 65 A. and 22 A. In the last case, where the ratio has narrowed to 3 : 1, we have practically reached the limit of applicability of the method. For this reason it is unlikely that the method will be applicable to untreated cotton at *p*H 7 owing to the small carboxyl content. In the presence of alkali, additional negative charges are developed by dissociation of some alcoholic hydroxyl groups. It may, therefore, be possible to apply the equation to measurements made with dilute solutions containing both chloride and hydroxyl ions. It may also be possible to increase the negative surface charge by absorption of surface active anions.

When the distance ratio has narrowed to unity, it is to be expected that the system will conform to the equation of the Donnan membrane equilibrium. This equation fits closely the measurements of Procter[3] on gelatine swollen in dilute hydrochloric acid. I regard this as evidence that the positively charged groups of the protein have a substantially uniform volume distribution in the jelly. The Congo red system investigated by Donnan and Harris[4] departs markedly from the Donnan equation, and this is in harmony with the view that the dye molecules are clustered into micelles. In a bentonite suspension the charges are so far from being evenly distributed that the Donnan equation is not even approximately obeyed. Mattson recognized the general implication of his results, which the theory of negative adsorption at a plane charged surface now enables us to interpret quantitatively. It is hoped that the application of this method to other colloidal systems will give interesting and useful information about the charge distribution.

[2] Mattson, S., *Soil. Sci.*, **23**. 179 (1929).
[3] Neale, S. M., *J. Colloid Sci.*, **1**, 371 (1946).
[3] Procter, H. R., *J. Chem. Soc.*, **103** (1), 313 (1914).
[4] Donnan, F. G., and Harris, A. B., *J. Chem. Soc.*, **99**, 1554 (1911).

PISTON CORE-SAMPLER

IN order to obtain long cores from the ocean floor two fundamental difficulties have to be overcome: first, the problem of imparting to the coring tube sufficient energy to embed itself in the sediments; and secondly, the problem of preventing thinning of the sedimentary layers inside the corer by friction between the sediment and the inner surface of the tube. Dr. Kullenberg's new core-sampler, developed in Sweden during the War, has been designed with the object of overcoming these difficulties[1].

In the normal gravity core-sampler, in which the coring tube is directly attached to the hydrographic wire, less than 50 per cent of the available potential energy is used in overcoming the resistance of the sediments, the greater proportion being wasted on useless work on the wire. It is for this reason, as well as because the kinetic energy of the instrument is low, that the depth of penetration is small, unless large driving weights are used. This difficulty has been overcome by means of a pilot weight and release mechanism, whereby the coring tube is released from its direct attachment with the wire at a predetermined distance above the sea bottom and allowed to drop freely through the water. By this means not only is it possible to give the apparatus a high initial velocity, but also a large proportion of the potential energy is converted into useful work, as that part of it which is not used in overcoming the resistance of the sediment and water is converted into kinetic energy. The efficiency of this new coring device is well shown by the fact that a 1,000 kgm. sampler, if released 6 m. above the bottom, penetrates 14 m. if the speed of unwinding is 1 m. per sec., whereas an equally heavy gravity core-sampler directly attached to the wire penetrates only 8 m. It is interesting to point out that a coring tube making use of free fall has recently been developed independently in the United States[2].

The difficulty created by the internal frictional resistance has been overcome by inserting inside the corer a piston which is joined by an appropriate length of wire to the hydrographic wire. It is arranged that the piston is kept stationary relative to the bottom immediately the corer strikes the sediment. As the tube is being driven into the sediment, friction creates a downward pull on the core; but this force is automatically balanced by the upward force due to the pressure difference between the mouth of the tube and the top of the core. The core has, therefore, a length equal to the depth of penetration. The problem of maintaining a stationary piston has been ingeniously solved by consideration of the elastic vibrations set up in the wire when the corer is released, and when the winch is stopped. It is shown that provided the corer, on approaching the bottom, is lowered at a speed corresponding to the velocity with which the cable shortens when the corer is released (in practice, owing to the friction of water on the wire the speed has to be slightly less), and provided the winch is stopped immediately the dynamometer indicates a marked reduction in tension, then the piston will remain practically stationary. The corer is placed inside a tubular external casing, which is left behind in the sediment if it is considered that excessive tension on the wire is likely to occur during withdrawal.

Dr. Kullenberg's new core-sampler is a great advance, and its development is undoubtedly one of the most important technical achievements which has been made in oceanography. That it is an efficient instrument at sea has been proved by its use in the Mediterranean in 1946 when cores as long as 15 m. were obtained from a depth of 2,620 m. All those interested in marine sediments and the history of the oceans are looking forward to the valuable results which will doubtless be obtained by its use during the present Swedish oceanographical expedition under Prof. H. Pettersson.

J. D. H. WISEMAN

[1] The Piston Core Sampler. By B. Kullenberg. *Svenska Hydrografisk-Biologiska Kommissionens skrifter*. Tredje Serien: Hydrografi. Band 1, Hafte 2, 1–46 (1947).
[2] Hvorslev, M. J., and Stetson, H. C., *Bull. Geol. Soc. Amer.*, **57**, 935 (1946).

VISUAL AIDS IN ADULT EDUCATION

ROYAL ARMY EDUCATIONAL CORPS EXHIBITION

By Colonel J. T. BURGESS

TEACHERS have for many years been counselled to make full use of illustrative material in their teaching; to appeal to the eye as well as to the ear; to vary the approach to their subjects; in fact, to stimulate interest and promote understanding by every means at their disposal. That the Army does not intend to lose the ground in this connexion gained under the impetus of war-time necessity was amply demonstrated at an exhibition of teaching aids held on September 15 at the Army School of Education, Eltham Palace, itself a most appropriate setting for an exhibition of this kind.

The extent to which the Army makes use of the film for training purposes is probably well known, but it may not be so widely appreciated that Army education is making use of the film and the film strip on an increasing scale. Two examples of films in use were shown to visitors, one on Palestine acquired to assist in teaching the men something of the background of the countries in which they may one day find themselves, and the other on teaching method for the training of instructors. On view, too, were some of the 189 film strips made by the Directorate of Army Education covering a wide range of subjects. The Army's agent for film and film strip work is the Army Kinema Corporation, which provides cinematograph entertainment throughout the Army and supplies mobile projectors for training and education purposes to the smaller units not equipped with their own 16-mm. projectors. There was an impressive array of the various types of standard equipment used by the Army Kinema Corporation and, what was perhaps of greater interest to educationists, a demonstration lorry constructed to show films in broad daylight.

Books were shown not entirely for their own value but also as an opportunity to demonstrate how much more attractive a library can be if it is housed, not in the forbidding gloom so often encountered, but in well-lighted and comfortably furnished rooms. This library was combined with the information room, and it was a place which invited one not only to stay and browse but also to come back again and again. Elsewhere in the exhibition was a stand to display the type of material issued for use in information rooms, and another to show the standard unit library of four hundred volumes which has achieved throughout the Army a popularity which is no small tribute to the skill of those who contributed to the difficult task of its selection.

In the field the Royal Army Educational Corps was charged with the duty of producing regular news sheets during operations in order to keep men in touch with the news of home and of the battle-fronts. This was, however, only an operational expedient; the production of proper Army newspapers is the function of the Army Welfare Service whose work in this field was amply demonstrated by a display of no less than fifteen Army newspapers drawn from all quarters of the globe. But it is not enough that men should merely read the news, they must understand its impact on their own lives and on the lives of their fellows, and to ensure that this important need is met instruction in current affairs and citizenship is a compulsory part of every soldier's education. To assist them to undertake this work, officers and other instructors require up-to-date material, examples of which were tastefully set out on two stands. Here the visitor saw the original British Way and Purpose pamphlets produced during the War by the War Office and afterwards republished in a bound volume, and a selection of "Current Affairs" and "Map Review" produced fortnightly by the Bureau of Current Affairs, civilian heir to the war-time A.B.C.A.

The immediate and enduring success of "Map Review" during the War pointed the way to an extension of the principle to other subjects, and a collection of double-sided poster sheets was displayed to show how this has been done: art, design in everyday things, economic geography, everyday science, languages have all been successfully treated in a manner which is at once simple and striking, and, since the designing is done by the staff of the Directorate of Army Education, each sheet can be directly related to the appropriate syllabus of instruction or devised to meet some special need. Great interest was shown in the first of a new series of these visual aids which aims to illustrate talks to the men on countries overseas where they may be required to serve. This first one dealt with Gibraltar, showing simply but vividly the importance of its position and, on the reverse, a large-scale map surrounded by photographs in sufficient variety to give the soldier a picture of the sort of place he will find on arrival. Similar sheets on Malta (of which a printer's proof was shown), Burma, Malaya, Palestine and Germany are already in preparation, so that the young soldier need no longer harbour a sneaking fear of the unknown. This new series is but part of a comprehensive plan which will embrace films, film strips and pictorial exhibitions, each type having a distinct purpose and the whole scheme related to the teaching of geography and history in the plan for the general education of the soldier.

Examples of pictorial exhibitions were on view elsewhere: these consist of series of twelve to twenty-four panels mounted on stiff board, each panel suitably captioned. More than two hundred of these are already in circulation and they cover a wide range of subjects. Among those on view were "Plastics", "Handicrafts", "Your M.P.", and a very fine set illustrating the beauties of the properties of the National Trust. Analogous to the pictorial exhibition is the photo service which began during the War when there was a dearth of pictorial newspapers. Restricted now to overseas commands this service provides fortnightly 150 sets of a dozen photographs covering topics of general interest and aimed to keep men abreast of the times.

To a very wide range of musical gramophone records the Army has added recordings of extracts of the speeches of Allied statesmen as a means of giving dramatic effect to talks on the history of the War; language records for use with the War Office text-books on half a dozen languages; sets on teaching method; a series on the approach to poetry and another on oratory. The B.B.C. also exhibited its contribution to Service education. The Forces Educational Broadcasts, first introduced as a part of the release period scheme of education, are still on the air and, although changed conditions have led to modifications in time and content, the B.B.C. continues to provide broadcasts of very high quality to assist service education, and the Army is now

including instruction in the use of this new medium in training courses for its young instructors.

An unexpected feature at this exhibition was the Foreign Office show-piece, "Germany Under Control", which has recently toured the country to explain the work of the Control Commission. It has now been secured by the Director of Army Education to visit recruit training centres and give young soldiers an opportunity to learn why we are occupying Germany and how the country is being administered. Thus they will be able better to appreciate why their own services are required. Seen against the remainder of the Eltham Exhibition, this feature with its mass of detail formed a striking contrast to the studied simplicity of the material specially designed for teaching purposes, but the expert knowledge of its special staff of lecturers, the life-size models, the bronze eagle recovered from the Chancellery in Berlin and Hitler's personal flag should all appeal to the troops, who are noted for their insistence on the real thing.

The presence of a large number of distinguished guests, both military and civilian, at this demonstration of the Army's efforts to assist its teachers and enliven their teaching shows that there is a wide interest in the progress of educational method. Certainly the Army has proved that education need not be dull, and the continuous requests for visual material received at the War Office from ex-Service teachers now back in their classrooms would appear to prove that Service experience has convinced many teachers of the considerable value of visual education.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Tuesday, September 23

TEXTILE INSTITUTE, LANCASHIRE SECTION (at 16 St. Mary's Parsonage, Manchester), at 7 p.m.—Miss A. G. Shaw: "Motion Study."

Tuesday, September 23—Thursday, September 25

FARADAY SOCIETY (in the Physical Chemistry Laboratory, South Parks Road, Oxford).—General Discussion on "The Labile Molecule".

Tuesday, September 23
At 2.30 p.m.

Wednesday, September 24
At 10 a.m. and 2.30 p.m.

Thursday, September 25
At 10 a.m.

Tuesday, September 23—Friday, September 26

INSTITUTION OF NAVAL ARCHITECTS.—Autumn Meetings.

Tuesday, September 23—Wednesday, September 24
At the Municipal College, Portsmouth.

Thursday, September 25—Friday, September 26
At the Civic Centre, Southampton.

INSTITUTE OF METALS (at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow).—Thirty-ninth Annual Autumn Meeting.

Wednesday, September 24

PHYSICAL SOCIETY (in the Physics Department of Imperial College, Imperial Institute Road, London, S.W.7), at 5.10 p.m.—Prof. F. Zernike: "Diffraction and Optical Image Formation" (The 15th Thomas Young Oration).

LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE (at Keppel Street, Gower Street, London, W.C.1), at 2.30 p.m.—Discussion on "D.D.T. and the Aeroplane in the Control of the Tsetse Fly and Trypanosomiasis in South Africa". (A colour-sound film prepared by the staff of the Onderstepoort Laboratory, Pretoria, will be shown and introduced by Dr. F. J. du Toit).*

Thursday, September 25—Friday, September 26

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY in collaboration with the INSTITUTION OF ELECTRICAL ENGINEERS.—Jubilee of the Discovery of the Electron.

Thursday, September 25
At 7.30 p.m. (at Central Hall, Westminster, London, S.W.1).—Sir Clifford Paterson: "The Electron Liberated".

Thursday, September 25—Saturday, September 27

SOCIETY OF DYERS AND COLOURISTS (in the Albert Hall, Albert Road, Blackpool).—Symposium on "Recent Advances in the Theory and Practice of Dyeing".

Thursday, September 25
At 10.30 a.m. and 2 p.m.

Friday, September 26
At 10.30 a.m. and 2 p.m.

Saturday, September 27
At 10 a.m. and 2 p.m.

Friday, September 26

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (joint meeting of the MICROCHEMISTRY GROUP and the PHYSICAL METHODS GROUP, at the University Chemical Laboratories, Cambridge), at 2 p.m.—Visits to the Colloid Science Department and Radiochemistry Laboratory; at 4 p.m. (in the Chemistry Lecture Theatre, Pembroke Street).—Short Papers on "Micro-physical Methods of Analysis".

MANCHESTER STATISTICAL SOCIETY, INDUSTRIAL GROUP (in the Lecture Room of the Society of Architects, 16 St. Mary's Parsonage, Deansgate, Manchester) at 6.45 p.m.—Mr. R. L. Plackett: "The Planning of Experiments in Industry".

Saturday, September 27

BIOCHEMICAL SOCIETY (at the School of Biochemistry, Tennis Court Road, Cambridge), at 11 a.m.—Scientific Papers.

Sunday, September 28

INSTITUTE OF ECONOMIC ENGINEERING (at the Waldorf Hotel, Aldwych, London, W.C.2), at 2.30 p.m.—Mr. J. Burgess: "Reflections on Productivity Assessment".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN BOTANY in the Department of Natural Science—The Principal, Technical College, Normanton Road, Derby (September 30).

VETERINARY INSPECTORS (approximately 100 vacancies), RESEARCH OFFICERS and ASSISTANT VETERINARY INVESTIGATION OFFICERS (approximately 40 vacancies)—The Secretary, Ministry of Agriculture and Fisheries, 23–25 Soho Square, London, W.1 (September 30).

PHYSICIST TO THE RADIOTHERAPY DEPARTMENT—The Secretary, Glasgow Royal Infirmary Office, 135 Buchanan Street, Glasgow, C.1 (September 30).

ASSISTANT LECTURER IN PHYSICS—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2 (October 1).

JUNIOR ASSISTANT PHYSICIST, for X-ray and radium work at Hammersmith and Lambeth Hospitals—The Medical Officer of Health (S.D.6), London County Council, County Hall, London, S.E.1 (October 1).

CIVIL ENGINEERS for maintenance and development work in the Works Division of the Ministry of Finance—The Assistant Secretary (Establishments), Ministry of Finance, Stormont, Belfast (October 10).

PRINCIPAL RESEARCH OFFICER IN THE FUEL RESEARCH SECTION of the Council for Scientific and Industrial Research—The Secretary, Australian Scientific Research Liaison Office, Australia House, Strand, W.C.2, quoting No. 1345 (October 11).

SENIOR LECTURER OR LECTURER, and a DEMONSTRATOR, IN THE DEPARTMENT OF ANATOMY—The Registrar, The University, Sheffield (October 11).

RESEARCH ASSISTANT TO THE PROFESSOR OF FUEL TECHNOLOGY and an ASSISTANT LECTURER IN MINING—The Registrar, The University, Sheffield (October 11).

PRINCIPAL SCIENTIFIC OFFICER, and a SCIENTIFIC OFFICER FOR CHEMICAL RESEARCH DIVISION, Ministry of Agriculture (N.I.)—The Assistant Secretary (Establishment), Ministry of Finance, Stormont, Belfast (October 15).

LECTURER IN SCIENCE (Biology), a LECTURER IN CHEMISTRY, LECTURERS (4) IN PHYSICS, and LECTURERS (2) IN MATHEMATICS, at the Royal Military Academy, Sandhurst—Director of Studies, Royal Military Academy, Sandhurst, Camberley, Surrey (October 15).

LECTURER IN CHEMISTRY—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1 (October 18).

LECTURER IN MATHEMATICS at Makerere College, East Africa—The Secretary, Inter-University Council for Higher Education in the Colonies, 8 Park Street, London, W.1 (October 18).

INSPECTORS (5) (Salmon and Freshwater Fisheries)—The Secretary, Ministry of Agriculture and Fisheries, 23–25 Soho Square, London, W.1 (October 18).

READERSHIP IN MORBID ANATOMY tenable at the Royal Free Hospital School of Medicine—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 23).

READERSHIP IN BIOLOGY tenable at Guy's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 28).

HEAD OF THE ENGINEERING DEPARTMENT—Principal and Clerk to the Governing Body, Wigan and District Mining and Technical College, Wigan.

LECTURER IN CHEMISTRY—The Principal, Technical College, Huddersfield.

LECTURER IN MECHANICAL ENGINEERING SUBJECTS for Crewe Technical College—The Director of Education, County Education Offices, (3/FHF), City Road, Chester.

LECTURER to take CIVIL AND MECHANICAL ENGINEERING SUBJECTS, with special reference to the Theory and Design of Structures, for the Technical College, Cardiff—The Director of Education, City Hall, Cardiff.